DIABETES MELLITUS:

A SYNOPSIS

OF ITS

PATHOLOGY, PHYSIOLOGY, ETIOLOGY, INCIPIENT AND
PROGRESSIVE SYMPTOMS, CAUSES OF DEATH,
SUGAR TESTS, AND TREATMENT.

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London:
SAMPSON LOW, MARSTON, SEARLE, & RIVINGTON,
CROWN BUILDINGS, 188, FLEET STREET.
1884.

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Dedicated,

WITH FEELINGS OF GREAT RESPECT AND REGARD, TO THE
RIGHT REVEREND THE

BISHOP OF NIAGARA,

WHO, WHEN ON A VISIT TO THIS COUNTRY SOME YEARS AGO, LED
ME TO TAKE A MORE THAN ORDINARY INTEREST IN
THE SUBJECT OF THIS MONOGRAPH.

PREFACE.

At the present time greater efforts than ever are being made by earnest workers in pathology, although heavily handicapped in their investigations by the new and arbitrary rules of the state, to trace out the remote cause of diabetes in the brain-structures; but, as in the political arena, so in the pathological one, there is a little "fourth party," which is giving a vast amount of trouble and vexation.

Pathologists, with almost prophetical instinct or inspiration, if we may so say, have pitched upon the fourth ventricle of the brain as the *fons mali*, but the keenest researches of our most astute observers have failed up to the present time to discover any very decided and constantly present lesion in the cerebral substance, nor, indeed, the slightest morbid alterations in the great cerebral centre, or structural irregularity, which must be always found in the post-mortem examinations, and one that we can point to as we can to the tiny white seed-like bodies found in the arachnoid membrane in tubercular meningitis, and say, here is the cause of the disease, or rather, here is the disease itself.

But, as Dr. Dickinson boldly stated at the meeting of the Pathological Society, during the discussion upon diabetes: "Diabetes must have a pathology." Let us hope, therefore, that sooner or later, as men's minds become more discerning, and microscopes are made more powerful, and the sections of the brain are sliced with greater nicety, so as to guard against any mechanical disturbance of its structures, that the long-looked-for lesions may duly present themselves to our admiring gaze. In the meantime pathologists must walk by faith but not by sight.

In this small volume, which is meant more as a *vade-mecum* than anything else, I have not pretended to propound any new theories of my own, nor herald any infallible remedy for this perplexing and harassing disease; my object has been more to summarize the latest knowledge which has come to hand respecting its pathology and treatment, &c.

HARVEY J. PHILPOT.

14, Finsbury Circus, E.C.

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DIABETES MELLITUS.

CHAPTER I.

PHYSIOLOGY OF DIABETES MELLITUS.

In the earliest periods of the world's history the disease we now term synonymously D. Mellitus, Glycosuria, Melituria, Glucohæmia, or Paruria Mellita, has existed, but alas, unrecognized till within the last 250 years. Physicians watched their patients becoming more and more emaciated; heard their complaints of intense and unappeasable thirst; listened with dismay and wonder to the oft-repeated tale of nights disturbed by frequent micturition, constant thirst, and voracious appetite; felt their hard, dry, feverish flesh, and looked at their smooth, red tongues; witnessed their looks of languor, and the distressed expression of countenance; noticed them growing paler and weaker day after day, till at last quite unable to attend to their daily duties, terminating their miserable existence unrelieved. What would those anxious and perplexed men have given to have possessed some of the knowledge we now possess of the treatment and management of a case of diabetes!

One cannot picture to oneself a more painful and distressing position for a physician to be placed in, than to feel conscious he is treating a disease—the full confidence of his patient being placed in him all the time—which he is entirely ignorant of, and therefore unable to administer any very palpable relief to.

From the earliest days when Paracelsus flourished till the days of Willis were our primitive brethren in this hopeless condition of ignorance, earnestly longing to help, and yet powerless to do so. Gradually, after 1600 years of bewilderment, light dawned upon them, the first ray coming from Willis in 1674, the second from Dobson in 1774, the third from Cowley in 1796, from the Continental physician Chevreul in 1815, from Tiedmann in 1825, assisted by Gmelin, McGregor, of Glasgow, in 1837, and finally, within the last three decades, from the great pathologist, Claude Bernard; and, to come nearer home, from Harley, Pavy, Lauder Brunton, Dickinson. and others. One after another drew aside the folds of the curtain which had so long veiled the mystery, and descanted to admiring listeners and readers upon the discoveries they had severally made.

Dr. Willis discovered the urine of certain of his patients to be sweet, for he had noticed some bees clustering round the spot where a diabetic patient had just before micturated. Dobson found the blood to contain saccharine matter. Cowley separated the sugar from the fluids of the body. Rollo, an army surgeon, suggested a purely animal diet. M. Chevreul detected the quantity and character of the sugar, while Tiedmann discovered that starch was converted into sugar during its passage through the alimentary canal.

McGregor separated the sugar from the urine. But it was left for the astute pathologist, C. Bernard, to prove, as he convincingly did in 1848, that sugar was actually manufactured in the human body. Up to this time the vegetable kingdom had borne all the discredit for the mischief done in the animal system. Dr. Harley soon took up the cue, and in 1853 discovered that diabetes might be produced by highly exciting the liver by alcohol injected into the portal vein, and it was this fact which so strengthened his theory that spirit-drinkers were more subject to diabetes than other persons. Other pathologists are still following up the subject, and before another decade has slipped away, all will doubtless be revealed to us of the real cause, nature, and pathology of the disease.

The term Diabetes—derived from the two Greek words *διὰ*, through, and *βαίνω*, to move or pass—is a generic one applied to two forms of the complaint, designated by the specific names D. Mellitus—from *μέλι*, honey, or *μέλιττα*, a bee—and D. Insipidus, or, synonymously, Polydipsia, Polyuria, or Hydruria. Each of these diseases has a distinguishing feature, namely, diuresis, but here the similarity ends.

In D. Insipidus no abnormal ingredient is found in the water, whereas in D. Mellitus a more or less quantity of grape-sugar is found always to exist. This latter form of diabetes has several synonyms, namely, Melituria, Glucosuria, and Glucohæmia. It is characterized by an excessive discharge of rather pale-coloured urine, of more than ordinary weight. The diuresis which accompanies it is, as we now know so well, only incidental to the disease, the kidneys themselves being in no way responsible for this morbid action, the irritant nature of the sugar only keeping them highly stimulated. In diabetes of long standing, however, as we shall find when we come to speak of the pathology of the disease, these organs do become ultimately enlarged and congested from the extra strain put upon them as eliminating organs; but this is an after-effect of diabetes, and these glands have no more to do with the primary cause of the disease than household drains are responsible for the effete matter which is eliminated by them. Diabetes has ceased, therefore, long ago to be classified in the category of kidney diseases.

From the Registrar-General's reports we learn the melancholy fact that this disease is rather on the increase. Let us hope, however, that this increase is more apparent than real, for in these days few cases of diabetes escape our notice, and each year our perception of them is becoming more acute, and patients, especially female ones, who so often keep their serious maladies so unselfishly secret, are becoming more open with their medical advisers; and, even if this was not the case, with our present familiarity with the appearances of the faces of those patients suffering from diabetes, their looks alone would betray them. Few persons in these days pass out of the world with their complaint unrecognized. In our American dependencies the disease is not so prevalent as in this country, which may be accounted for, doubtless, by the difference of climate. In America the air is bright, clear, and bracing, whilst in England it is dull, and damp, and relaxing, bracing often, but enervating and dispiriting oftener.

In 1851 . .	403	persons fell victims to diabetes.
1852 . .	402	” ” ”
1853 . .	412	” ” ”
1854 . .	436	” ” ”
1855 . .	448	” ” ”
1856 . .	443	” ” ”
1857 . .	482	” ” ”
1858 . .	514	” ” ”
1859 . .	480	” ” ”
1860 . .	536	” ” ”
1861 . .	537	” ” ”
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1868 . .	671	” ” ”
1869 . .	735	” ” ”
1870 . .	735	” ” ”
1871 . .	805	” ” ”
1872 . .	769	” ” ”
1873 . .	827	” ” ”
1874 . .	882	” ” ”
1875 . .	940	” ” ”
1876 . .	910	” ” ”
1877 . .	1006	” ” ”
1878 . .	1057	” ” ”

In 1880, 624 males and 435 females died in Great Britain of the disease.

In the following tables we shall see the number of deaths which occurred in the two sexes at various periods of life:—

MALES, 624.

Under one year, only one died.

At the age of .	1	2	3	4	5	10	15	20	25
Died	3	2	0	1	5	13	32	37	92

At the age of .	35	45	55	65	75	85
Died	101	90	146	75	24	2

FEMALES, 435.

At the age of .	1	2	3	4	5	10	15	20
Died	3	2	1	1	9	14	20	25

At the age of .	25	35	45	55	65	75	85	95
Died	56	63	64	93	67	16	1	0

Of these, 84 males died in London in 1880, and 78 females.

Starch plays such a very prominent part in the physiology of diabetes that perhaps it will be as well, before proceeding further, to trace out something of its origin, where it comes from, and what its uses are in the animal economy.

To begin with, starch is one of the three oxidizable carbo-hydrates, or heat and force-producers of the body; sugar and fat being the other two. Starch, however, is the most important one of the group; for it is the greatest heat-giver or force-producer in the food we eat. It is of the highest importance to become familiar with it, and to know exactly where to find it, if we wish to treat diabetes with any degree of success. It is found in all cereals, more especially in rice, wheat, and maize, also in potatoes, and in many esculent and succulent fruits and vegetables. The shape of its granules characterize the plants it belongs to. They are white and glistening, and do not dissolve in cold water, but very readily in hot. Iodine turns it intensely blue.

Prof. Church has drawn up the following table of the proportionate amount of starch found in various vegetable products :—

In a hundred pounds of—

Sago, tapioca, and arrowroot, there are	83 lbs.
Pearl barley	76 ,,
Rice	76 ,,
Fine wheaten bread	74 ,,
Wheat and rye	71 ,,
Scotch oatmeal	63 ,,
Buckwheat, without husks	64 ,,
Maize	64 ,,
Millet, without husks	61 ,,
Peas	51 ,,
Haricot beans	49 ,,
Wheaten bread	48 ,,
Wheaten bran	44 ,,
Potatoes	15 ,,
Parsnips	3 ,,
Vegetable marrow	0½ lb.

To make starch digestible it must be boiled. During mastication of food the ptyalin, or the natural ferment of the saliva, converts a portion of it into dextrine, and this process of conversion is carried on as the starchy food continues to pass along through the stomach and intestinal canal, where it comes in contact with the pepsin, the succus entericus from the glands of Bruner, the pancreatic juice, and, in fact, the various ferments of the successive digesting organs through which it passes, all of which are more or less albuminous compounds, especially those of the small intestines.

Dr. Pavy says that starch, as was formerly supposed, is not converted directly into sugar by these ferments, but into substances of far lower cupric oxide reducing power, namely, dextrine and maltose; maltose having a cupric oxide reducing power compared to grape-sugar or glucose as 61 is to 100. He states that the process of converting dextrine and maltose into glucose is attended by increased hydration. As starch is to the vegetable world, so is glycogen, of which further mention will be made later on, to the animal; the two are almost identical.

In the diabetic Dr. Pavy's theory is, that the chemical order of transformation is reversed, and the carbo-hydrates are converted at once into glucose, which appears in the blood, and is then carried direct to the kidneys.

A new kind of ferment is set up in the liver, the result of an over-arterial supply to it. The ordinary venous blood going to the liver converts the carbo-hydrates into maltose; but if a surplus amount of blood flows through the liver, the carbo-hydrates are then transformed into glucose. Starch is of no use in the animal economy as such, it must undergo the changes as before described.

Sugar is the second oxidizable carbo-hydrate which our attention must be directed to. There are several varieties of it: grape, cane, beet, corn-stalk, and maple-sugar, which latter is extracted from the beautiful tree emblematic of Canada, the *Acer saccharinum*, which contains two per cent. of saccharine matter in its sap.

Sugar is contained in the following substances in the proportions specified :—

In 100 pounds of—

Dried carrots, beans	51 lbs.
Sugar-cane juice	18 ,,
Beet-root	11 ,,
Chinese sugar-grass	9 ,,
Maize-stem juice	7 ,,
Sugar maple	2 ,,

But the sugar which we have to deal with in diabetes is grape-sugar, or glucose. This is also obtained from the vegetable kingdom, and can be made from starch, dextrine, and sugar-cane by the addition of an acid. It is, in fact, manufactured at the present time in London from sulphuric acid and starch, being used largely by brewers in place of malt.

If we add sulphuric acid to wood-fibre, cotton, linen rags, cellulose, or the substance found in paper, grape-sugar will be formed. So that, as Prof. Church says, " Spirits can be made from old rags and waste pawnbrokers' tickets," the grape-sugar thus made being so fermentable. This kind of sugar crystallizes in minute rhombic, transparent crystals, which are devoid of colour, and in sweetness and solubility rank between cane-sugar and sugar of milk or lactose. The formula for it is $C_{12}H_{24}O_{12}$; dextrine and maltose being formulated respectively, $C_{12}H_{21}O_{10}$ and $C_{12}H_{22}O_{11}$. It forms beautiful crystals with chloride of sodium, nearly three-quarters of an inch in length.

One form of grape-sugar is dextrose, and another lævulose, and a third maltose. The former exists in such sweet fruits as grapes, and we recognize it at once as crystals upon all dried fruits. Lævulose does not crystallize, but forms a sticky mass; it is the principal ingredient of honey. The grape-sugars are not so sweet as the cane-sugars, but are much more easily digested. If too much is ingested lactic acid is formed, producing indigestion, heartburn, and other ill results. Maltose is the sweet product of malt, or sprouted barley, and, as we have already seen, is one product arising from the action of diastase or the ferment of the saliva upon the starch of the food we eat. Milk-sugar, from which the now almost extinct globule of the homeopath was made, and probably its most important factor, has many of the properties of grape-sugar. Cow's milk contains five per cent. of it. It is, perhaps, the least sweet of the sugars. It will be as well to mention here that cane-sugar when boiled with an alkali is not decomposed, whilst grape-sugar when thus treated is converted into an acid, namely, melassic acid. But, as we have noticed already, cane-sugar is converted into grape-sugar by the addition of an acid to it.

We shall see further on how this conversion of grape-sugar leads to its detection in urine by what is termed Moore's test. Sugar has to become transformed into glycerine and lactic acid in the system before it is fit fuel for the blood. It may be found in the tissues of the body in excess owing to an insufficiency of the natural ferments necessary to convert it into lactic acid and glycerine; or else this irregularity may be due to an altered condition of the sugar which would enable it to resist the action of the ferments; or, again, diminished circulation through the muscles would prevent the sugar being brought into contact with the ferments. These are some of the suggestions thrown out by Dr. L. Brunton, as to the probable cause of glycosuria, in his highly interesting lecture upon the subject delivered in 1874.

It appears that when diabetes arises from increased manufacture of sugar in the liver, flesh diet does not check its formation so much as it does when the disease depends upon a defect in the glycogenic process. Why, " under ordinary conditions, sugar should be the result of natural ferments of the body, and not at other times," is the great problem for pathologists and physiologists to solve.

When very much sugar accumulates in the blood another kind of fermentation rapidly converts it into acetone or aceto-acetic acid. It is this acid which produces the excessive acidity of diabetic urine.

Healthy blood always contains more or less sugar, as C. Bernard, Dr. Dobson, and others have demonstrated, but in very such minute quantities in healthy life, that it is hardly traceable in the urine.

More is found in the arterial blood than in the venous, and the quantity has been proved to increase by exertion of the muscles.

Dr. Pavy's experiments go to prove that there is not more than the 50,000th or 60,000th of a grain per cent. in healthy animal blood. The blood drawn from the carotid artery contains a little more than this amount. It is in excess after epileptic or other convulsions, and any cause which produces an overflow of arterial blood to the liver will cause an eflux of sugar from the kidneys.

Claude Bernard did not hesitate to say that the liver was a sugar-manufacturing organ, and he believed that the sugar formed in it passed upwards to the venous system, entering it by the vena cava inferior, and so into the heart and lungs; the liver, therefore, performing a twofold purpose of forming bile and sugar at the same time. This formation of sugar in the system is termed glycogenesis, from γλυκὺς, sweet, and γεννάω, I beget. The sugar-forming material is termed glycogen or amyloid substance. Bernard first named it glycogen. Others called it zoamylin. Pavy suggested that it should be named bernardin after its discoverer. It is generally known now by the name amyloid substance. It is formed in the hepatic cells when the organ is in a healthy condition. This glycogen partakes of the nature of starch and dextrine, and is placed by Pavy in the carbo-hydrate group; its formula is $C_{12}H_{12}O_{12}$.

The supporters of the glycogenic theory supposed that not only was the starch and sugar ingested conveyed into the circulation at once, but that, as has been before mentioned, the liver was constantly keeping up a supply of this material, and sending it to the blood through the hepatic vein. The theory was that in health the sugar underwent combustion in the lungs through the action of the inspired air, its oxygen going to the blood and its carbon escaping in the form of carbonic acid in the breath, or, in other words, that the sugar was destroyed by oxidation in the lungs. Some went so far as to say that the liver itself, without the assistance of ingested starch and sugar, could keep up the supply of sugar to the blood.

The generally recognized theory, however, now is that this breaking up of sugar takes place in the peripheral capillaries, especially of the muscles, where it undergoes combustion, which results in the production of carbonic acid and water. It is this combustion constantly going on which keeps up the heat of the body, during muscular exercise more especially. One great problem which pathologists and chemists had to solve was whether there was greater ingress of sugar to the system in diabetes, or whether the destruction of the carbo-hydrates was in proportion to the amount admitted. Of course, if this latter was not the case an enormous accumulation of sugar would take place in the body, and the urine would become charged with it.

Claude Bernard was of opinion that there was an exaggeration of the formative process, or, as Dr. Harley put it, "an excessive formation, not a lessening of expenditure from defective assimilation or mal-nutrition." C. Bernard held that sugar was found in the blood in large quantities, but Pavy proved very convincingly that the sugar Bernard found in his experiments was the result of a post-mortem action. Pavy extracted blood from live animals, by catheterism, from the hearts of animals, and found but infinitesimal traces of it, and he experimented most carefully upon livers placed in ice and in boiling water immediately upon removal from the body, so as to prevent any post-mortem fermentation taking place in them, and found but little sugar in their tissues. C. Bernard contended that as long as the sugar remained in the proportion of one part only in a thousand of the blood diabetes did not present itself; but as soon as this proportion was raised above this amount, then it presented itself in the urine, and we had diabetes to deal with as a disease.

As long as the liver is able to assimilate the sugar, and so prevent it getting in any large proportion into the general circulation, the equilibrium is held perfect between its ingress and its egress; but as soon as this equilibrium is lost from the causes above mentioned, then we have the symptoms of diabetes presenting themselves. It has been proved that animals which are fed entirely upon a vegetable diet have no more sugar in their blood than the carnivora, if anything, rather less. The amyloid substance found in the hepatic cells, according to Pavy, is not only derived from ingested sugar, but from nitrogenous matter as well; for if we feed a diabetic patient on lean meat, carefully excluding all fatty and starchy food, we can still detect sugar in the urine, although none of the carbo-hydrates have been partaken of in the food. He accounts for this phenomenon taking place owing to the nitrogenous matter in the food becoming split up into its various component parts, portions of which go to form urine and the rest to form the amyloid substance; the nitrogen going to form the former, and the carbon and hydrogen the latter.

Professor Haughton is of the same opinion. The action would appear to be carried on through some glucose-forming ferment in the liver. According to this theory the liver has two sources from which it manufactures amyloid substance, namely, one from the ingested sugar, and the other from the nitrogenous material left over from the manufacture of urea. Let us hope that this manufacturing business is carried on in a very small way; for if we have to deny our patients nitrogenous food as well as all starchy foods, we may as well tell them to go home and die of starvation.

The next step taken by the glycogen in the hepatic cells seems a little doubtful. Here Pavy and Bernard are again at variance, for the former tells us that it does not become converted into sugar, thereby annihilating the glycogenic theory. Bernard, on the other hand, contends that the glycogen is converted into sugar, and is carried direct to the peripheral capillaries.

The great point to be decided is where the sugar is formed and how it reaches the kidneys. Dr. Harley produced abundance of sugar in the urine by injecting alcohol into the vessel leading to the liver, thereby stimulating it and causing a greater supply of blood to flow into it; he produced the same result by irritating it with needles. He says that any stimulant acting upon the hepatic branches of the pneumogastric nerve will produce diabetes through the nerve-centres from which the influence is reflected to the liver. In the ordinary course of events cane-sugar, when taken into the system, finds its way to the liver, to be stored up there as glycogen, which in its turn is generally supposed to be converted into grape-sugar.

Bernard found that when a large quantity of cane-sugar, such as we ordinarily consume with our food, is taken into the body, a portion of it will be carried off directly by the kidneys, without undergoing any change whatever. This he terms "normal alimentary glycosuria." Dr. Dickinson says, if we accept the preponderating theory that sugar is a proper issue of glycogen, we may see in diabetes an excessive formation of this liver-starch.

Dr. Pavy considers that this transmutation of sugar is only a cardaveric change, or else the result of nerve-injury, all the nervous influence required for preventing glycogen being changed into sugar being lost. He quite disbelieves in Bernard's theory that sugar is made from the glycogen in the liver during life, and in proof of his unbelief details in his "Researches" the result of his elaborate experiments upon the blood of living animals and the livers of dead ones. But he asserts that when glycogen is introduced into the blood when it is warm and circulating during life, it is converted into sugar owing to the presence of some ferment coming in contact with it. But he holds that the glycogen in the liver is not converted into sugar whilst in the liver-cells till the moment of death, and hence the error Bernard was led into in concluding that the sugar he found in the liver on the "post-mortem" table was an ante-mortem production.

Drs. McGregor and Prout maintained that sugar was formed by the digestive organs. Dr. Dickinson says that Pavy's theory of the cardaveric change may be partially correct, for it does not negative the one which allows of sugar being formed during life. Dr. Dalton agreed with Pavy in thinking that glycogenesis was both ante- and post-mortem.

Dr. Lauder Brunton considered that sugar appeared in large quantities owing to an insufficiency of the natural ferment in the muscles, or to some irregularity in the sugar itself, which prevented the fermentation going on in it, and converting it into glycerine and lactic acid, or to a diminished circulation of blood through the muscles.

CHAPTER II.

PATHOLOGY.

The pathological conditions of the nerve-centres in diabetes still remain very obscure, but, owing to the brighter light which has been thrown over the subject of late by pathologists, we must hope that this obscurity may be penetrated before very long.

Early writers seem to have had but vague ideas about diabetes; indeed, they had no pathological theories about it whatever. They generally blamed the kidneys, and never concentrated their attention upon any other source, and certainly not the brain and spinal cord.

The pathologists of to-day, without exception, refer the causes of diabetes to some lesion in the fourth ventricle, or thereabouts, and no one hardly now contradicts the theory that some kind of cerebral lesion takes place as a primary cause of the disease, either in the floor of the fourth ventricle, or in some other portion of the medulla oblongata.

The discovery has been made by some pathologists that sugar can be formed in the urine by irritating not the diabetic centres only, as was before supposed, but by irritating the sympathetic ganglia themselves anywhere above the second dorsal vertebra. By thus paralyzing *pro tempore* the vaso-motor nerves, relaxation of the hepatic vessels takes place, a greater amount of arterial blood is carried to the liver, and immediate glycogenesis takes place. So much more sugar is formed than when the organ is in its natural condition, that it very quickly shows itself in the urine. This experiment, if carried to the extent of severing the nerve, will cause permanent diabetes.

In like manner, if the great sensory nerve of the liver, the pneumogastric, is cut across, and the upper or proximal extremity is irritated, congestion of an arterial character is produced in the organ, and sugar rapidly collects in the urine. This remarkable result is caused through the medium of the sympathetic nerve. Claude Bernard demonstrated this in 1851. Dr. Brown Séquard disputed the conclusion he came to in the following year, and stated that neither direct nor indirect irritation produced this effect, but rather the contrary. Schiff was of opinion that paralysis of the vaso-motor nerves produced diabetes, his opinion coinciding with that of Claude Bernard, Drs. L. Brunton, Pavy, and other pathologists. So much is this theory believed in at the present time that we may almost look upon it as an established fact.

It must be borne in mind that the liver does not receive all its nervous power from the brain direct which is required to stimulate it to secrete sugar, for that stimulus is in a great measure produced by the act of inspiration of air, which excites the pulmonary branches of the pneumogastric nerve, and is so carried to the liver. By irritating, indeed, any of the great nerves, sugar can be sometimes made to appear in the urine. In many severe cases of sciatica we can detect its presence there. But, on the other hand, we frequently have disease of the spinal cord itself without any trace of saccharine material being discovered escaping from the kidneys. This is accounted for by the fact that the grey matter of the cord, in which the vaso-motor nerves have their origin, is not implicated in the disease. German writers tell us that, when the system is under the effect of profound coma from anæsthetics, irritation of the nerve-centres does not cause the appearance of sugar; but we must not lose sight of the fact that sugar is found in the urine when the blood is impregnated with chloroform, although the sympathetic nerve may not have been irritated in the least.

Let us now inquire what appearances there are visible in or upon the brain and its substance in those persons who have died from glycosuria.

Strange to say that in many, we might say, indeed, in the majority of cases, there are no lesions to be observed at all. Dr. Dickinson's opinion is that the following is a characteristic change which takes place in it: A dilatation of the arteries and enlargement of the perivascular spaces in the medulla, which appears to permit of the escape of the contents of the blood-vessels, followed by a softening and destruction of the nerve-substance around them. Some observers state very positively that they have not seen this condition of things, while others again say they have seen them occasionally.

Dr. Dickinson describes a peculiar cribriform appearance of the cut surface of the brain, as if drilled with pin-holes, each minute channel containing a minuter blood-vessel. Sometimes he has observed holes large enough to contain a pea, especially in the substance of the pons Varolii in connection with the processes of the pia mater.

He says he has noticed these various changes in no less than eleven consecutive cases. The channels or excavations were round about arteries, or in the localities where arteries had been. Their shape is somewhat globular and elongated, like narrow tunnels, denoting the course of the vessels.

The cause of these cribriform processes he considers to be the result of absorption of nerve-substance in the immediate neighbourhood of the arteries, sometimes caused by the escape of the contents of the vessels, which produces degeneration and softening, and finally the removal of the nerve-matter.

Dr. Dickinson has detected by the aid of the microscope, clusters of crystals of hæmatin centering round the vessels. These holes are found not only in the pons, but in the medulla oblongata, cerebellum, and optic thalamus. So riddled was the last-mentioned body with them, that he compared this portion of the brain to Gruyère cheese or volcanic lava. The white matter of the convolutions he described in some instances as being most peculiarly cribriform, each containing a small artery, round which the crystals of hæmatin were clustered. The same appearance of things he found, but in a less marked degree, in the cord itself. The most remarkable change, however, which he found here was a dilatation of the central canal of the cord. He found the dilatation to be greater in the dorsal and lumbar regions. It was more than double, and even treble its natural size in its transverse diameter: sometimes to the extent of $\frac{1}{24}$ of an inch. It has been proved to demonstration, however, that these conditions are not peculiar to diabetes, and indeed it is uncertain if this disease is in any way associated with those changes.[1]

He found also miliary sclerosis of the white substance of the encephalon. It is difficult, however, to prove that these pathological changes are due to diabetes, or that the latter disease is due to them.

Diabetic blood is not irritating to the tissues, although sugar itself is very decidedly so, as is so painfully illustrated in cases of pruritus and eczema.

Dr. Dickinson thinks these are the pathological changes which give rise to diabetes. It is, apparently, only in the white matter of the brain these alterations of structure are observed.

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[1] In October last there were several specimens exhibited at the Pathological Society's rooms, of dilatation of the spinal canal. Dr. Moore showed one in which the canal was dilated to the size of a finger, and another in which pus in large quantities had found its way through the fourth ventricle into the sub-arachnoid space and canal of the cord. Dr. Taylor had shown on a previous occasion a specimen in which a large cavity had been formed in the cord. It was generally allowed by the members that such large cavities and dilatations had rarely, if ever, been seen before, and yet in none of these cases were there symptoms of such morbid alterations having taken place, and no symptoms of glycosuria were present in any of them.

Dr. White stated, during the discussion that took place upon diabetes at the society's rooms, that in twenty-three post-mortem examinations held at Guy's Hospital, no vacuolation was found in the nerve-centres whatever, nor indeed was there any morbid change found in the brain-structure. He produced many specimens of brains, both of diabetic patients and non-diabetic patients, and in the former one of the brains showed somewhat the appearance of vacuolation, but this evidently was the result of the vessels having fallen out of their spaces.

He showed sections of the brain from non-diabetic patients in which the vacuolated or Gruyère-cheese condition was distinctly marked.

Dr. Mackenzie had examined fourteen cases, in none of which had any particular change taken place in the brain-structure.

In six cases he found peri-ganglionic vascular dilatation formed, but he was not sure as to the extent this mischief occurred during post-mortem disturbances and in their preservation.

In six cases intra-alveolar hæmorrhagic extravasation had occurred, but only in those cases in which death had followed coma.

Hyaline degeneration was found in kidneys and spleen. The liver only showed fatty degeneration in one case out of eleven. Some of the livers showed atrophy of cells. No changes were remarked in the pancreas.

In diabetics the kidneys are often found enlarged and congested, as one would naturally suppose them to be, hypertrophy being nothing uncommon in eliminating organs which have an unnatural strain thrown upon them; therefore this appearance must not be looked upon as pathognomonic of the disease.

Dr. Stanilaus Ponocklo, of Cracow, paid particular attention to the microscopic examination of the sympathetic nerve and its ganglia, and in several of his post-mortem inspections he excised the whole nerve, and before submitting it to the lens he hardened it. He states that in all the cases he thus examined he found structural changes had taken place in the connective tissues of the ganglia, especially in the cervical ganglia; the accumulation of new connective tissues being very distinctly seen in sections of the ganglia. To so great an extent had the connective tissue collected that the nerve-tissue itself had nearly disappeared. He found also numerous nerve-cells infiltrating the tissues, especially round the blood-vessels.

Atrophy of nerve-cells and fibres was the result of hypertrophy of connective tissue, as is usually the case. Ponocklo was therefore of opinion that nerve-degeneration of the cervical sympathetic ganglia is the pathology of diabetes mellitus.

He considered that the amount of mischief which he found was about equivalent to the destruction of the nerve-tissue.

Some French writers associate diabetes with splenic lesions. They assert that in certain exaggerated forms of diabetes they have found morbid alterations in that organ, and they endeavour to strengthen their statement by saying that when animals have their spleens extracted symptoms such as present themselves in diabetes supervene. That is to say, the animals become voracious in their appetites, and emaciated in their bodies, and soon die. One of these theorists goes so far as to state that on consideration of the above-mentioned phenomena he must conclude that there exists a causal effect between changes in the pancreas and the disease diabetes.

Dr. Silver exhibited before the Pathological Society a specimen of spinal cord which he had removed from a patient who had died of diabetes. It presented the following appearances: Great congestion and a blood-clot outside the sheath of the cord, opposite the third, fourth, and fifth dorsal vertebræ. Lower down there was a considerable amount of gelatinous material surrounding the dura mater. There was also vascularity and capillary injection of the pia mater, softening of the cord opposite the third and fourth cervical vertebræ, and also in the dorsal region at a spot corresponding to the hæmorrhage in the canal. The brain itself was hyperæmic, especially at the left side, and the island of Reil on the same side was softened. The patient was a lad of nineteen years of age. He was thin and weak, and had well-marked diabetes. Dr. Silver pointed out that the softening of the cord was in the tract along which the vaso-motor nerve-fibre ran which supplied the liver, this path being from the medulla along the spinal cord to the vertebral artery, and thence to the middle and lower cervical sympathetic ganglia, the first dorsal ganglia, and the plexus on the cœliac axis. There did not appear to be any softening in the floor of the fourth ventricle. These appearances must not be considered at all pathognomonic, for in the examination of other bodies which have died from such marked diabetes no such pathological anatomy was to be discovered at all.

It would be most gratifying if some such appearances were always found, for then we might have something tangible to work upon, both in the treatment of the disease and its pathology, but up to the present day no infallible morbid alterations of any of the structures, either brain, glandular, or muscular, have been found indicative of diabetes.

Dr. Finlay detailed before the same society the results of death from diabetes in which the human tissues presented quite different appearances to those which were noticed in Dr. Silver's case. In his case the muscles were found of a dark red colour. The mesenteric glands slightly enlarged. The lungs engorged and friable, and the pancreas the seat of a small hæmorrhage. The liver was normal. Spleen small and pale. Kidneys normal. The pia mater was injected, the brain substance *firm, and in every respect normal to the naked eye, as were also the cord and its membranes.* I put the foregoing in italics to attract attention to the difference in the appearance of the nerve-tissue in the two specimens. Dr. Finlay went on to state that in his case there was nothing to suggest an essential pathology.

According to reports of post-mortem examinations held at our various hospitals, the *liver* appears to be the organ principally to blame. Out of twenty-nine autopsies held at St. George's Hospital nineteen showed this region more or less altered in structure. Hyperæmia was the condition chiefly observed. Next in frequency, fatty degeneration and induration. In these twenty-nine cases no general tuberculosis was found. The hyperæmic condition of the liver was produced most probably from some brain-irritation acting through the sympathetic nerve.

In the blood of diabetes an excess of fat and water is generally noticed, especially of the former, but the proportions of the other elements remain the same, except, of course, sugar, which is found in more or less quantities, but as the normal amount of this material is so infinitesimal in healthy blood, we might almost term it a foreign body.

With regard to diabetes in connection with insanity, Dr. Dickinson made some very interesting inquiries into their relationship at the Bethlehem Hospital. He analyzed 106 specimens of urine of insane patients with the following results: In 59 no reduction of copper took place. In 29 only traces of sugar were observed. In 15 cases decided reduction was found to take place. In 3 cases only was there considerable reduction. In 14 out of the 106 the urine boiled dark with liquor potassæ. Albumen was found in 4 cases out of the whole number. The cupric oxide reduction was most marked in cases of mania acutus and melancholia.

So much doubt existed in the minds of pathologists as to the conditions observed in the pathological specimens exhibited at the society's rooms, that a committee of investigation was appointed to investigate them. The following is the report drawn up and presented to the society by Drs. Savage, Gowers, and Payne :—

"Having examined and compared the various sections of tissues from diabetic subjects, we have come to the following conclusion : Some of the sections certainly present appearances such as are not seen in typically normal tissues. Some of these, such as the miliary bodies, irregular staining, &c., are clearly the result of faulty methods of preparation. Others must be considered as the result of changes during life.

"In many sections the peri-vascular spaces are of considerable size, but neither their size nor their number exceeds that which is frequently found *post mortem*, apart from diabetes or any nervous disorder.

"In one specimen—No. 10 of Dr. Dickinson's—the number and size of the spaces excite surprise, but the section is from beneath the corpus striatum, where numerous and large arteries enter the brain-substance. Granular and amorphous matter, such as is seen in some of the specimens within the peri-vascular spaces, is frequently found in such spaces whatever was the cause of the death of the subject examined.

"In some specimens there is evidence of recent and old hæmorrhage, small in amount, around the vessels, but this is such as is often met with in various diseases, and after asphyxial modes of death.

"We fail to find any abnormal bulging or dilatation of the vessels, large or small. On the whole we found the changes in the medulla to be less marked than those in the cerebral hemispheres.

"No significance can be attached to the occlusion or dilatation of the central canal of the cord, even when as marked as in Dr. Dickinson's specimen No. 20. In the one specimen of sympathetic ganglion the pigmentation in the cells is not abnormally great. We have failed to find in the specimens submitted to us any changes which can be regarded as exclusively, or even constantly, associated with diabetes.

"Oct. 2, 1883."

CHAPTER III.

ETIOLOGY.

Most physicians will agree in the opinion that the one great first cause of diabetes is nerve-shock, either physical or mental. Severe blows on the head have been known to produce it. Several of our hospital reports relate cases of injury by falls or blows upon the head giving rise to the disease. Tumours encroaching upon the great pneumogastric nerve is another cause; a clot of blood pressing upon that portion of the brain in the immediate neighbourhood of the medulla oblongata, the pons Varolii, for instance; extravasation of blood into the peri-vascular spaces; injury to the sympathetic nerve; ramollissement of brain; some forms of indigestion; intemperance in systems predisposed to the disease by heredity; and long exposure to cold—these and other physical causes we shall find giving rise to diabetes. Grief of mind, a harassed brain, sudden imparting of bad news, are all mental causes of diabetes, especially if that disease is hereditary in the patient's family.

In the latter part of the seventeenth century various strange and fantastic notions gained ground as to its primary causes. Dr. Willis, physician to Charles I., whose name was made so familiar to us when the mysteries of the base of the brain were disclosed to us at the commencement of our medical studies, quite convinced himself that diabetes resulted from drinking too much beer and cider. This would doubtless account for the diuresis which accompanies the disease; but Dr. Willis, although he discovered the saccharine character of the water, never looked beyond this symptom, and the origin of the sugar remained a mystery.

Dr. Keil thought that from drinking too much spirit the serum of the blood became in a great measure converted into it.

Dr. Mead seems to have been the first physician who called attention to the fact of the liver being implicated in diabetes, but, unfortunately, he knew but little of the physiology of that organ, and therefore he terms it a "distemper which produced a vitiated condition of the bile, and caused the fat or oil," as he quaintly terms it, "of the liver to be thrown down." He states that he often found a steatomatous collection in it. Some of his contemporary physicians would not allow this theory to be a correct one, for the reason that jaundice would always be the result of such disturbance in the hepatic structures, and jaundice they were aware rarely showed itself in diabetes.

In the year 1745 what was termed a "mechanical inquiry" was instituted at Oxford into the nature, causes, seat, and cure of diabetes, for little if anything was really understood about it, and the result of the inquiry did not throw more light upon it.

Eighteen centuries ago Aretæus, a Cappadocian physician, had spoken of it as "miraculam quondam." He supposed it to be a sort of dropsy, and concluded that the solid parts in the body were dissolved into urine, as they were into water in dropsy.

Galen himself had only seen two cases of it, and his great master, Hippocrates, was doubtless no wiser about the disease than Galenus Claudius himself. If Galen's books had not nearly all been burnt at Rome during the conflagration of the Temple of Peace, we might perhaps have been able to give him more credit than we do for successful investigation into its mysteries. He considered it arose from "imbecility" of the kidneys, and thought that those organs attracted the urine from all parts of the body. But Galen's reasoning was weak, although his imagination was so vivid and fertile.

Celsus, the Epicurean philosopher, as it may doubtless be remembered by those who have "passed the hall," says very little about it.

Some thought the diuresis arose from the passages to the kidneys being too large and open; they seemed unaware that the urine came from the blood itself. Others again thought that some poison collected in the blood which by its action was melted down and even some of the tissues themselves were turned into fluid.

Dr. Randolph, in the early part of the eighteenth century, wrote a treatise upon diabetes, but he showed a great want of pathological knowledge in his theories. Among other causes he gives for it, is the bite of a poisonous snake, which had the effect of producing mortification of the kidneys. He mentions hypochondriasis as often being a precursor of diabetes, but throughout his treatise he blames the kidneys and their relaxed ducts. Stone in the kidney he charges with it. He was quite under the impression the disease was glandular, but which glands were to blame "deponent sayeth not." He speaks of a lacteal diabetes in a woman, and mentions that all the fluids of her body ran out at her breasts. This case very much strengthened him in his glandular theory. Of late years diabetes has been so thoroughly and scientifically inquired into by pathologists, physiologists, and chemists, that we are in a position now-a-days to speak with more certainty of its causes, physiology, and treatment.

That diabetes is a hereditary disease has been proved beyond a doubt.

If we question our patients, we shall very often elicit from them that either consumption, insanity, epilepsy, diabetes, or some other exhausting malady had been a skeleton in the family cupboard. We find it more frequently among Jews than Christians, which curious fact probably may be accounted for by the more saccharine diet they partake of.

The male sex appears to be more susceptible to the disease than the female, doubtless owing to the more exposed life they lead, and the more mind-engrossing cares and anxieties they have to endure in the battle of life.[1] Woman has to bear more of the petty worries of domestic life, which to her doubtless are equally burdensome, but they do not tax the brain so heavily. The greatest number of people die from diabetes between forty and sixty years of age, but if we compare the mortality with the number of people living, we shall find that actually the proportion is greater of people dying of diabetes between sixty-five and seventy-five. Very young people are certainly not so liable to the complaint, but it is much more fatal to them. Cases are reported of young children suffering from diabetes, but they are very rare indeed. As we approach, on the other hand, the opposite extreme of life, we find the disease becoming chronic in its nature, and much less fatal—that is to say, old persons die *with* the disease, but not so frequently *of* it. Very fat people appear more liable to diabetes than spare people, but it does not take that hold upon them, for they have plenty of tissue to feed the disease with. Like a ship sinking from overballasting, she may be kept afloat by heaving portions of it overboard.

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[1] In the twenty-nine autopsies held at St. George's Hospital, twenty-three were on men, and only six on women.

There is a form of glycosuria, which writers term hepatic; it is transitory in its nature, soon subsiding under judicious treatment.

We find it in gouty people and in those who surfeit themselves with rich foods. By dieting and medically treating these cases very carefully the sugar will disappear *in toto* from the urine.

A strumous habit of body appears to favour the disease; and long residence in cold and damp districts, till the body has become half-starved from its effects, and its blood depraved. A residence also in a miasmatic district favours the disease. Rheumatism and gout and repelled skin diseases are supposed to be exciting causes. But even all the causes I have enumerated are after all only problematical. Sudden bursts of anger have been followed by glycosuria in the same manner that other sudden nerve-shocks have turned the hair grey.

Too long a strain upon the intellectual powers, prolonged anxiety in business, intense suspense while great danger is threatening, excessive sexual indulgence, and dissipation long continued, are all more or less causes of brain-lesion resulting in diabetes.

Men die rather later than women. In elderly people, however, the disease is more chronic, and it does not produce that amount of systematic disturbance. Occupations and localities play a very decided part in increasing or reducing the mortality from diabetes.

Thus it is more frequent in rural districts than manufacturing ones, that is to say, among agricultural labourers than among mechanics and artisans, and in cold counties like Norfolk, Suffolk, and Lincolnshire, than in warm counties like Somersetshire and Devonshire. Exposure to weather and poorness of food in the one case predisposes, while the better living and more comfortable surroundings of the manufacturing classes more or less protect them.

Cider districts do not appear to be invaded by the disease any more than others. So the theory of the older physicians falls through.

CHAPTER IV.

INCIPIENT AND PROGRESSIVE SYMPTOMS.

All physicians, from time immemorial, who have paid any attention to diabetes, and have handed down the results of their experience, agree in stating that the first symptoms noticed of the approach of the disease is a failure of nerve-power, even in those forms of the disease in which the general health does not appear to suffer so much in the onset of the attack. An indescribable feeling of inertness steals insidiously over the body, a kind of chronic condition of *malaise* like the premonitory weakness of an approaching illness. *Pari passu* with this debility the patient voids a great deal more water than usual, but this fact hardly claims his attention till he has on several occasions been disturbed in his slumbers by his bladder becoming inordinately full. Each night this trouble increases, till micturition becomes incessant, and his bed is no longer a source of rest and comfort to him. At the same time he discovers that his clothes begin to sit loose upon him, and his friends call attention to the fact of his losing flesh. This strikes him as being a strange phenomenon, for he knows but too well that his appetite has been increasing rather than abating, and that besides eating more than usual he has become more thirsty than heretofore, and has drunk a great deal of various fluids, not only during his meals, but between them, and not only during the day, but at night also when he gets out of bed to micturate.

As the disease advances on its course the thirst becomes almost intolerable, and he greedily swallows any fluid he can get hold of, even the muddy water which is left on the road after a shower of rain, if he is out of reach of a better supply. So much water has been carried out of the blood that nature keeps up a constant demand for it, in order, if possible, to support the equilibrium between the fluids and solids in the body.

In spite of all this drinking the thirst seems to increase yet more and more, and the tongue becomes red and glossy-looking, and the mouth dry and clammy, with a fringe of mucus round the lips, which dries brown like a high-water mark.

Matters have reached such a pass that his life has become a burden to him. Eat what food he may, and what quantity of it he can, the gnawing and sinking at the pit of his stomach still continues. It has now become a race between waste and supply. Such a large amount of solids are passing away through the kidneys that the gap left has to be filled up somehow, but as long as the reckless use of starchy food goes on it is like piling fuel on to the fire. Sugar-fermentation is in full swing. The salivary glands now cease to act, which is another great source of distress; for the food rolls round his parched mouth, and he can hardly get it down the dry channels of his throat. The excessive dryness of the system produces obstinate constipation, which becomes a very troublesome complication. This constipated state of the bowels, however, sometimes gives place to an opposite condition, and we have a diarrhœa to contend against which weakens the patient dangerously; the skin has become very dry and harsh, especially in the palms and soles.

Diaphoresis occasionally takes place, giving a somewhat temporary relief to the sufferer. So much material has by this time been drained away by the kidneys that the body has become much emaciated, the face especially looks shrunken and drawn. The general distress is depicted on the countenance, which looks anxious and careworn. In man all desire fails, although virility may return with the strength under judicious treatment. In woman the catamenia often cease, but return as the disease moderates. Older authors speak of the hips and legs swelling, but this is by no means an invariable result, unless, of course, actual disease of the kidneys is present. Owing to the low state of vitality, boils and carbuncles and other evidences of such a condition present themselves, in consequence of which tendency all sources of irritation to the skin must be prevented, and such irritants as leeches and blisters must be strictly avoided.

In females a very distressing symptom is often present, namely, pruritus vulvæ, produced by the irritating nature of the saccharine urine. This is often the first signal of distress hung out by nature. When therefore a woman comes to consult us for an intolerable itching of her external organs of generation, we must at once test her urine for sugar, for it may be present in that fluid as a cause of the cutaneous irritation, although there may be no polyuria, voracity of appetite, or inordinate thirst denoting diabetes. In man we find irritation set up frequently round the orifice of the urethra from the same cause. In some diabetic patients a peculiar lactescent condition of the blood is found. This creamy or milky appearance is caused by the large amount of fatty matter accumulated in it, and is termed lipæmia or pionæmia—from πῖος, fat, and αῖμα, blood. This is not, however, peculiar to diabetic blood, but it is observed more frequently in the blood of diabetic patients, because animal food forms such a large share of their daily diet. A similar milky condition of the circulating fluid, but in a lesser degree, may be noticed in the blood of a person who has partaken of a meal rich in fatty constituents. We cannot therefore associate this condition of blood exclusively with diabetes, as some seem to think.

The addition of certain acids to healthy blood increases the amount of fat in it, and this has led some writers to the conclusion that the aceto-acetic acid which is produced in the blood of diabetics causes the lactescent appearance.

This fatty accumulation in the sanguineous fluid may give rise to fatty embolism and fatty degeneration of the liver and other organs of the body, which is sometimes observed after death from diabetes. Diabetic patients often complain of pains in their legs and hips, and a sensation of chilliness in their extremities; although, as has been observed, they may have burning sensations in the soles of their feet and palms of their hands. In some cases symmetrical changes take place in the lenses of their eyes; a kind of hard cataract forms. It is difficult, however, to connect this affection with diabetes.

It may be perhaps the direct effect of sugar-poisoning, for Dr. Weir Mitchell in America experimented upon frogs, and found that, by injecting sugar in strong solution—of a specific gravity over 1045—under the skin of a frog, its crystalline lens became opaque. The gums have a tendency to become spongy in diabetes, and the teeth to decay. Lung-disease of a nature peculiar to the disease creeps on insidiously. It is not so much of the nature of tubercular phthisis as a breaking down of the lung-tissue from a low state of vitality generally—in fact, from the same condition of system that gives rise to gangrene in the legs, and boils and carbuncles in various parts of the body—all being indicative of a degraded condition of the system generally. Dr. Adison considered this lung-affection was albuminoid. It presents all the symptoms of phthisis, but the post-mortem examination proves the distinction existing very clearly. A chronic inflammation destroys portions of the lung-tissue, forming cavities, but we find no tuberculous deposit. Here we have again the result of a poison circulating in the blood, destroying its healthy and invigorating action on tissues.

It was this blighting influence of the saccharine blood which evidently established the theory among older physicians of putrefaction of that fluid. Sometimes we have acute pneumonia set up, which is very apt to carry off the patient suddenly; or, again, a sudden stagnation or stasis of the blood may take place in some vital organ after much exertion, exposure to cold, or other enervating cause, and prove fatal to the patient.

The digestive powers being much weakened and lowered in tone, gives rise to troublesome flatulence and acid eructations which cause much annoyance. The eyes sometimes become sore and weak, and altered in appearance from changes taking place, more especially in the retina, a condition ophthalmologists term amblyopic, from *ἀμβλὺς*, obscure, and *ὦψ*, vision. The eyes seem to have lost their natural clearness and brightness of expression. Dyspnœa is often trying to the patient, and he suffers from a distressing sense of constriction at the præcordia. There is a tendency to sigh frequently, and the patient feels listless mentally, and he becomes fretful and peevish in his temper. The pulse is variable, and later on in the progress of the complaint becomes weak and irregular. The temperature is generally below the usual standard, and in a few exceptional cases it has been found as low as ninety-six. Often it rises rather suddenly, denoting rapidly increasing combustion going on in the system.

We shall generally find in those cases of glycosuria which have their origin in over-production of sugar, when the patient is fleshy and apparently robust, a higher temperature; and in those cases where there is a diminished consumption, and consequently more or less emaciation, we shall find the temperature is lowered. All the symptoms I have detailed in the last few pages are painfully apparent to the patient, but he may not, up to this time, have become aware of the fact that he is suffering from diabetes. He becomes for the first time conscious of the real state of affairs in the consulting-room of the first physician he appeals to for assistance; his secret is then disclosed by the urinometer and test-tube. Upon making our discovery we must be very careful not to inform him of his malady too abruptly, but, on the other hand it is absolutely necessary to take him more or less into our confidence, in order that he may assist us in the treatment of his case. But let me give a hint, *en passant*, to my younger *confrères*, and that is never to allow their patients to watch the process of testing their urine. I recollect, some time ago, a gentleman from the country coming to consult me, and when I was examining his urine, some distance from him, and with my back turned towards him, I heard a sudden exclamation of horror close to me, and, upon looking round, found my patient had crept up quietly and peeped over my shoulder to watch the process. He saw at a glance at the test-tube his disease was growing worse, and this revelation destroyed evidently his only chance, for the disappointment was so great to him that I believe he went straight home and died very shortly. He had been under the care of another medical gentleman, who had, doubtless in pure kindness, deceived him as to the progress of his malady.

Again, if the medical man does not give the patient some idea of his disease, his friends will sooner or later undeceive him, and, perhaps, more roughly; for in these days "there is not much hid which will not be made manifest" by the discerning public.

Upon examining the urine in the first instance with the urinometer, we find it, perhaps, so heavy that the bulb of the instrument rises buoyantly with its stem, half-way to the surface of the fluid, probably marking as high a degree as 1045, or even 1060 if the amount of saccharine substance is very large; but we must not from this phenomenon alone jump to the conclusion that our patient has diabetes mellitus, for there are other conditions of the urine which produce elevation of specific gravity.

In azoturia, or great excess of urea, we find a very high degree of specific gravity, although there is no sugar present at all. Great loss of urea from the system produces most distressing bodily weakness and nervous depression, owing to the general atrophy of tissue which is constantly going on, and this symptom, in conjunction with the high specific gravity of the water, might deceive us still further.

Diabetes, azoturia, albuminuria, phosphatic deposits, are all more or less associated with destruction of tissue, and accompanied by great debility; we must therefore extend our examination in all cases further yet, and proceed to apply what are termed sugar-tests to the urine.

But while on the subject of urea it may be as well to make a few further remarks upon it.

In the first place, it is the principal organic constituent of all urine. Its symbol is $C_2H_4N_2O_2$, and it contains nearly eighty per cent. of the nitrogen excreted. A healthy man of average size passes about 500 grains of it in twenty-four hours; of course, if he partakes very freely of animal food, eggs, gelatinous substances, &c., he will pass a great deal more proportionately. In its pure state urea presents itself in white crystals, sometimes appearing as fine silky needles, and at others as four-sided prisms. If we add nitric acid to an equal quantity of urine which is charged with the salt, crystals of nitrate of urea soon make their appearance.

It may come from two sources, either from the nitrogenous food taken or from wasting tissues. It is of vital importance necessarily to know whether it is from the latter or not. If bodily exercise is carried too far, that is to say, to the extent of great fatigue and exhaustion, the muscular tissues are compelled to yield up their albuminous constituents, and we then find nitrogen in the form of urea passing from the kidneys. Sometimes we find fever existing with excess of urea, and at other times failure of the digestive functions, and consequent nervous debility. Dr. Prout was of opinion that azoturia might in time develope into diabetes.

The diet we are called upon to order in this complaint is very different to that which we would recommend in diabetes, for in the former we prescribe a farinaceous as well as a nitrogenous one; the farinaceous part of it would prove probably fatal to the diabetic.

In diabetes very frequently a large amount of urea is carried off by the kidneys with the sugar, owing to the quantities of animal food eaten. We have to bear this in mind when we examine the urine. This salt, as has already been remarked, raises the specific gravity of the urine, and, at the same time, upon the addition of Feyling's solution to it, a decided discolorization takes place, which might be taken for slight cupric oxide reduction. These two tests, therefore, namely, the specific gravity one and the copper test, both require supplementing, in order that perfect accuracy of diagnosis may be arrived at.

The calculation has been made that upon a purely animal diet a man will pass about 1400 grains of urea in 24 hours, and upon a purely vegetable one only 400 grains, and upon a non-nitrogenous, or one only containing fat and sugar and starch, only 250 grains of this salt will be eliminated in the 24 hours. Dr. Haughton stated that the nitrogenous portion of our food, when taken into our systems, is divided in the liver into sugar and urea. The nitrogen going to form the urea, and the carbon and hydrogen the glycogen which is there found. Excess of urea sometimes preceding glycosuria, and sometimes accompanying it, led Dr. Prout to remark, "This alternation of a principle containing nearly half its weight of azote with another containing no azote at all is one of the most singular facts occurring in physiology." There is no doubt that cases of diabetes have followed those of azoturia which have been allowed to go on unchecked; but it is very difficult to trace cause and effect between the two maladies, and to say whether the diabetic attack was really *propter hoc* or *post hoc*.

A simple method has been proposed for

making a somewhat rough estimate of the solid material found in urine, and that is by multiplying the excess of the specific gravity over 1000 by 2·33; the result will show the number of parts of solid matter per 1000 parts of urine. Dr. Prout gives the proportionate amount of solid matter in urine having a specific gravity of 1020 up to 1050 in the annexed table.

Solid Matter in a Pint of Urine.

Spec. Grav.	Grains.	Spec. Grav.	Grains.
1020	382·4	1036	689·6
1021	401·6	1037	708·8
1022	420·8	1038	728·0
1023	440·0	1039	747·2
1024	459·2	1040	766·4
1025	478·4	1041	785·6
1026	497·6	1042	804·8
1027	516·8	1043	824·6
1028	536·0	1044	843·2
1029	555·2	1045	862·4
1030	574·4	1046	881·6
1031	593·6	1047	900·8
1032	612·8	1048	920·0
1033	632·0	1049	939·2
1034	651·2	1050	958·4
1035	670·4		

In many cases of diabetes dropsy is present, but this is not a *sine qua non.* The peculiarity of diabetic dropsy is that the kidneys, at the time of its presence, frequently go on discharging large quantities of water. This is probably the result of an anæmic condition of the system, similar to the dropsy we find in those people with very impoverished blood, and which is so greatly benefited by tincture of iron.

The impression seems to prevail that this dropsy continues to the last, but this is a mistake, for it sometimes disappears entirely under proper treatment. The swelling of the limbs has not that peculiar hard and unresisting feel which it has in non-diabetic dropsy. The limb is much softer, and there is but little pain in it; and the œdema confines itself to the legs and thighs. Gangrene sometimes shows itself in the toes of old diabetics, especially in those cases where there are complications, such as boils and carbuncles, which waste the strength and tend to increase the depravity of the system. It has been known to follow the application of a common fly blister. Albumen occasionally shows itself in the urine after long irritation of the kidneys from the sugar, and these organs become, as we have seen when upon the subject of pathology, enlarged and vascular.

Diabetes may begin to show itself very suddenly, with well-marked disturbance of the system, and terminate fatally very soon; and on the other hand, the disease may last as long as fifteen years.

CHAPTER V.

CAUSES OF DEATH IN DIABETES.

Coma is certainly the most frequent cause of death in this disease. Some statistics go to prove that half the deaths arise from it.

Diabetic coma, as it is termed, is ushered in with acute pain in the epigastrium, arising probably from a sudden congestion of blood in the region of the diaphragm, or the pain may be referred more to the hypochondrium. Very frequently delirium, either quiet or noisy, may be present, following severe pain in the head. There is increased action of the pulse, vomiting, and diarrhœa. Over-exertion or any mental shock may precipitate the seizure, which has certain characteristics distinguishing it in a measure from other forms of coma arising from fractured and depressed bone impinging upon the surface of the brain, or from blood-clots in apoplexy, or uræmic coma. The breathing, for instance, is peculiarly laborious, but, as writers describe it, more panting than stertorous, and although the lungs may be quite sound, the patient appears to be struggling for his breath as if there was some terrible impediment in the breathing apparatus.

The coma comes on often very insidiously, and may pass off again for a time, giving false hopes to the friends, for it generally returns and closes the scene effectually sooner or later. A coldness steals over the body, and the skin and mucous surfaces become livid in appearance. The pulse becomes more rapid and smaller, the temperature is lowered even to 95° Fahr., and there is sometimes incontinence of the urine. The breath is peculiar in its odour, being compared by some to a mixture of chloroform and ether, by others to aldehyde, or chloroform mixed with acetic ether, while others, again, resemble it to that produced by sour beer. When such is the case, the addition of perchloride of iron will turn it into a purplish brown, or Burgundy red colour, denoting the presence of acetone; hence the term acetonæmia.

I may allude here to that very strange phenomenon which presents itself, but so very rarely, when the urine is highly charged with sugar, and a fermentation has set in from some cause or another, termed pneumaturia, or an escape of gas from the bladder through the urethra subsequently to micturating. There is no smell to the gas whatever. The question naturally arises: Is this gas the result of the admission of some germ from the outside into the bladder, or is it the result of sugar fermentation from a cause within the body?

Formerly this coma was supposed to be uræmic, but it has been proved beyond any doubt that it arises from the toxic effects of acetone. Dr. Ralfe considers that acetone, although found largely in the urine, does not circulate in the blood itself as such, but as aceto-acetic acid—the ethyl diacetate of some writers—and he further thinks that it is this acid which gives the lactescent condition to the blood, as it is well known to act powerfully on fatty substances, and he considers that it is this same acid which produces fatty degeneration of the tissues.[1]

Another theory was that coma arose from a dehydration of the blood, but salines have been introduced into the veins without any good

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[1] The following letter from me appeared in the *British Medical Journal* of Feb. 24, 1884, which is rendered interesting by the answer given to it by the editor:—

"Sir,—May I be permitted to inquire through your columns of some of the scientific readers of the *British Medical Journal* whether it is possible, during the formation of acetone from the decomposition, as Dr. Ralfe states, of ethyl diacetate, or, as he prefers to term it, aceto-acetic acid, in the body of diabetic subjects, for a gas to be formed which would account for that rare phenomenon pneumaturia.

"The process of decomposition or fermentation, as we are well aware, causes the evolution of carbonic acid gas. The question arises, might not this gas be formed in the blood results being obtained, except in a very few cases.

Other causes of death have been mentioned, as fat embolisms, hyperglychæmia, and fatty degeneration of the heart, alteration of epithelium of kidneys, or hyaline transformation; but these changes have been rather the exception than the rule.

The most accredited theory, however, at the present time is that of vaso-motor paralysis, of

and give rise to the sudden coma of diabetes? and if it form in the blood, could it not form in the urine as well, and produce pneumaturia?

"I am, &c.,

"Harvey J. Philpot."

"⁂ Our correspondent's suggestion is plausible. Pneumaturia, when it occurs, seems to be parallel to those cases of extreme flatulent distension which we sometimes meet with in hysterical and hypochondriacal patients. The suddenness with which this comes on in these cases, and the fact that it occurs often on an empty stomach, point to a rapid diffusion of gas from the blood. This diffusion is generally attributed to nervous influences, but it may possibly occur from an over-formation of carbonic acid gas in the blood from fermentation changes. Of this we have no evidence as yet. In considering the subject it would be necessary to distinguish true pneumaturia from mere frothy urine, which is more or less a mechanical condition; also from any carbonic acid formed in the bladder attendant on the decomposition of urea.

"Our correspondent may consult, on the subject of diffusion of carbonic acid, Dr. C. H. Ralfe's recently published 'Clinical Chemistry,' p. 227.—Ed. of *British Medical Journal.*"

the vessels of the chylo-poietic viscera more especially, permitting a superabundance of arterial blood to flow through the liver, and hence a large amount of oxygen, which leads to the formation of sugar, setting up rapid fermentation in the blood and resulting acetonæmia. The aceto-acetic acid, or acetone, the result of acetous fermentation, produces effects akin to alcoholism, when, that is to say, it has accumulated in large quantities. From statistics of deaths from diabetes at the London Hospital, extending over a period of eight years, coma appears to have caused death in nineteen cases out of thirty-seven, or a little over half the number, and from pneumonic phthisis in nine cases. It has generally been considered that there was a causal affinity existing between phthisis and glycosuria, but from statistics made by Dr. Power, of the Brompton Hospital for Consumption, it seems to be rather a rare concomitant,for in 165 specimens of urine examined, which was passed by patients in various stages of phthisis, no sugar was detected. Phthisis often presents itself in diabetes, but the latter does not appear to occur very often in patients with phthisis, although we are all aware that diabetes presents itself frequently in very wasting diseases.

In fifty-three cases which died in Guy's Hospital in one decade, thirty-three died comatose, but in very few indeed of these cases did the most careful post-mortem examination disclose any structural lesion which might have been the primary cause of diabetes. Death may occur suddenly from syncope arising from cardiac paralysis.

The most common cause of death, however, is coma, varying in degree of intensity and length of period. It is of the utmost importance to be able to diagnose a case of diabetic coma, when called to it without a previous knowledge of the patient. Diabetic coma has many points of semblance to other forms of coma, but on the other hand, more especially in the character of the breathing, it very decidedly differs from any other kind of cerebral seizure that we are conversant with. It will perhaps, therefore, be as well to enumerate the various symptoms which are more or less prominent in coma arising from acetonæmia, apoplexy from depressed bone or blood-clot, uræmia, and alcoholism.

DIABETIC COMA.

Symptoms more or less observable.

Approach rapid, sometimes insidious; increasing prostration and weakness; headache of a severe character; restlessness and anxiety; sudden pains at epigastrium; pulse quick and feeble, and often irregular; nausea and vomiting; occasionally hæmatemesis; uresis at first, suppression of urine eventually; diarrhœa. Breathing typical, namely short and panting, or sighing, not stertorous, or snoring, as in apoplexy—resembling, as pathologists describe it, the rapid and distressed breathing of an animal with its vagi severed. Delirium, sometimes noisy, but as often quiet, according to character of the disease and condition of system. Patient may be roused. Temperature lowered, more so than in apoplectic coma; etherish or acetous smell from breath; inspiration and expiration both loud and harsh; eyelids not paralyzed, but when lifted fall again very slowly. A short rally sometimes takes place, followed by deeper coma; cyanosis. Time of seizure from 24 to 120 hours. When perchloride of iron is added to the urine during the presence of comatose symptoms, the characteristic Burgundy red colour is produced in it.[2] Sugar present.

A most interesting report of two cases of diabetic coma, by Dr. Southey, will be found in the *Lancet* of Feb. 8th, 1879, with remarks appended, and I would refer the reader to Dr. Bond's and Mr. Windle's report of a typical case of diabetic coma in the *British Medical*

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[2] Some authors state that this condition of the urine upon the addition of the ferric chloride is not peculiar to the comatose state, but that it shows the Burgundy red colour at other periods of the disease as well.

Journal of May 12th, 1883. It would have interested us still more had some notice been taken of the amount of sugar passed daily during the comatose state.

The actual cause of the coma is probably blood-poisoning from the accumulation of sugar, and hence the suggestion that it should be termed glycohæmia, or sugar in the blood, as in albuminuria the blood-poisoning from urea is termed uræmia. Dr. Bond and Mr. Windle seemed to think that these cases of diabetic coma in the Birmingham Hospital supervened on a diet rich in albumen and poor in starch. They found the urine increased rapidly in quantity after adding meat to the diet of their patients suffering from advanced diabetes. In two out of the three cases these gentlemen report tapeworms, *T. medio-canellata*, were found in large masses in the lower part of the small intestines.[3]

APOPLECTIC COMA.

Precursory Symptoms.

Intense headache; giddiness and fulness of head, with feelings of great oppression, noises in ears, loss of memory, difficulty in pronouncing words, numbness and want of power in limbs. If from bone-depression, onset sudden; prolonged in clot-formation.

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[3] Dr. Pavy is of opinion that coma is the ordinary way in which persons die who have had their diet partially controlled, and that in those cases where the disease has been allowed to run on unchecked the probability is that death will result from pulmonary mischief.

In carus, or the intense form of coma, patient cannot be roused; entire loss of consciousness, motion, and sensibility; face flushed or pallid; not always failure of heart's action; pulse full, may be slower and irregular and intermitting, according to circumstances of the case; deglutition impeded; breathing stertorous, with flapping of cheeks, slow and irregular; convulsions sometimes present; no struggling. Limbs in carus, flaccid; in other cases, rigid on one side and contracted. Pupils dilated; if pressure on one side, opposite pupil dilated, if bilateral, both. Sometimes they are contracted, and in some cases not much change is noticed, but in carus they are generally widely dilated.

Urine in this extreme form of coma escapes involuntarily, and the fæces likewise. The former may be retained persistently. Facial or other paralysis present. Temperature at first slightly lowered, but not so much as in diabetic coma; rises subsequently if patient lives over twelve hours. No alcoholic or etherish aroma from breath. No sugar present in urine.

URÆMIC COMA FROM TOXIC EFFECTS OF UREA IN BLOOD.

Urea converted into carbonate of ammonia by fermentation, the character of which is not known.

Symptoms in earlier stage are headache, giddiness, dimness of sight, and delirium, noisy or quiet ; œdema of eyelids, face, and limbs. Urine diminished in quantity or totally suppressed, charged with albumen, and of low specific gravity. Frequent convulsions, somewhat resembling epilepsy, but the premonitory cry is absent, and the patient is sometimes conscious. Subsultus tendinum and twitching of muscles of face are present. Pupils fixed and dilated, or, under certain conditions, contracted as in narcotic poisoning. Breathing differs from apoplectic snoring and from acetonæmic panting ; it is quick and harsher in sound, not such a decided snore as in apoplexy, nor so laborious and distressing as in diabetic coma. Coma rapidly deepens, and death soon follows.

ALCOHOLIC COMA.

Symptoms.

Continued drowsiness in slight cases. In actual coma, total insensibility ; no power of motion ; breathing stertorous ; countenance not much changed in expression or appearance, frequently pallid; pupils generally dilated; pulse slow, sometimes quick and small; temperature very much reduced; skin cold and clammy; alcoholic breath; limbs flaccid, impartially; no paralysis.

Dr. Ralfe states that many of the symptoms attendant upon death from acetonæmia resemble those of death from acute yellow atrophy of the liver in phosphorus-poisoning—namely, sudden pain at epigastrium; vomiting; sometimes vomit mixed with blood; peculiar dyspnœa; short noisy delirium; fall of temperature; irregular pulse, rising rapidly, and falling as quick; and deep coma.

Dr. Tanner details symptoms somewhat similar: burning and tenderness at pit of stomach; vomiting of dark matter; and diarrhœa; great prostration, and convulsions.

Dr. Gamgee alludes to a fatal case of acute diabetic coma in which the liver was found infiltrated with fat similar to the condition found in cases of poisoning by phosphorus.

In Dr. White's report of twenty-two fatal cases of diabetes in Guy's Hospital—

9 died from coma;
4 from pneumonia;
4 from phthisis;
2 cause not mentioned;

1 typhoid and coma;
1 carbuncle;
1 gangrene of lung.

Probably the next most usual cause of death in glycosuria is acute lung-affection, and more especially acute pneumonia. After great exertion or exposure to cold, we sometimes find death resulting from sudden stasis of the blood in some vital organ.

Dr. Roberts mentions two cases of sudden death which came under his notice, and which he attributed to the patient's supply of water being cut off.

CHAPTER VI.

TESTS FOR SUGAR IN URINE.

Qualitative and Quantitative Tests.

To continue with the examination of our diabetic patient. Having found certain of the symptoms present which have been before mentioned in the chapter appropriated to diabetic symptoms, we must next proceed to analyze the urine, in order to satisfy ourselves that sugar is present, and if we find it is so, our examination must extend to the discovery of what quantity of saccharine material is escaping from the body *viâ* the kidneys. To find this out we have at our disposal several tests, both qualitative and quantitative, which we must carefully enter upon the consideration of. A great many qualitative tests have been introduced by various medical men and chemists, some of which have been found wanting, and therefore discarded, while others, again, although still in use, do not deserve to have much credit awarded to them, owing to their inaccuracy and consequent unreliability.

The earliest test that was instituted for the detection of sugar was, I believe, that of Dr. Cruikshanks. It consisted of the addition of nitric acid to the urine, which converted the sugar into oxalic acid, throwing it down in crystals; then followed—

Hünefield's Test, which is used thus: Pour four ounces of the suspected urine into a glass vessel, and then expose it to the sun's rays; in a little while add six drops of tolerably strong solution of chromic acid. In a few minutes, if sugar is present, the orange-red mixture becomes brownish, and soon afterwards assumes a bistre-red, or wood-soot colour. The mixture of chromic acid should be warmed first. The acid becomes reduced, by the oxidizing power of the sugar, to oxide of chromium. This is not, however, one of the most reliable tests, for non-saccharine urine may produce a like effect, providing there be much colouring matter in it.

Runge's Test.—A small quantity of urine must be evaporated on a white surface, the bottom of a plate for instance, and while it is warm let fall upon it a few drops of dilute sulphuric acid, in the proportion of one part to six. In healthy urine the part touched by the acid will become merely of a pale orange colour, owing to the various colouring matters in it; but if sugar is present, it becomes deep-brown, and ultimately black, owing to the decomposition of the sugar by the sulphuric acid, which has deposited carbon. This test will detect one part of sugar in over a thousand parts of urine; but in Runge's test we have not infallibility, for if albumen is present, much the same kind of effect is produced.

Moore's is certainly the simplest of the sugar tests, although it is not sensitive enough for all cases of diabetes. It is as follows:—

Pour a little of the suspected urine into a test-tube, and add half its bulk of liquor potassæ. Boil this mixture for a minute or two, and if sugar is one of its ingredients it will gradually change in colour, till finally it becomes of a very dark brown appearance.

The glucose is converted into melassic acid under the influence of the caustic alkali. It must be borne in mind, however, that half a drachm of liquor potassæ, boiled with twice the amount of saccharine urine, will not indicate less than two grains of sugar in the ounce; and, again, the caustic may have been kept in leaden bottles, which is apt to impregnate it with that metal. If such is the case, and there happens to be albumen in the urine under inspection, a chemical combination takes place between the sulphur in the albumen and the lead, and a dark sulphide of lead is formed, which might be mistaken for melassic acid, and lead to an error in diagnosis very serious in its results.

The Crystallization Test. — Evaporate the urine to the consistence of syrup, and digest the residue in hot alcohol.

Allow this to evaporate in a large test-tube, and crystals of sugar will be seen on the side of the glass as white granules.

M. Maumene, of Rheims, proposed what was termed the chloride of tin test. He saturated a piece of white merino, which is not affected by the compound, in a solution of chloride of tin, and then poured a little of the urine over it, which he desired to test, and dried it at a temperature of 300° Fahr. If any sugar was present, a dark brown stain was produced, denoting the presence of grape-sugar.

The *tasting test* is as unreliable as it is filthy; for diabetic sugar, as found in the urine, unless in large quantities, is by no means very sweet to the tongue.

The most reliable test before the copper ones had been brought to their present degree of delicacy was the *fermentation test.*

All liquids containing vegetable matter and sugar are capable of undergoing vinous fermentation. When exposed to a heat of from 65° to 85° Fahr., they undergo a series of changes resulting in the formation of alcohol or spirit, sugar, and some ferment—an essential to this chemical metamorphosis—but when the sugar has served its purpose it disappears as such from the fluid entirely, being converted into carbonic acid and alcohol. The calculation is, that out of forty-five parts of sugar twenty-two parts of carbonic acid are formed, and twenty-three of alcohol.

But sugar alone in water will not ferment, it requires the presence of gluten in the solution, or the albuminoid, or flesh-forming matter, or fibrin, of wheat or dough, with all the starch washed out of it. This gluten absorbs oxygen from the air before it can act as a ferment upon the glucose or sugar contained in the solution. In bread-making the process of fermentation is assisted by the addition of yeast to the dough. This latter substance is closely allied to gluten, containing, like it, a large amount of nitrogen.

It is produced during the vinous fermentation of vegetable decoctions and juices. It is a viscid, frothy matter, insoluble in water and alcohol, and putrefies in a warm atmosphere. The simplest case of fermentation is that observed in *must*, the expressed juice of the grape, which at a temperature of 70° Fahr. gives off carbonic acid, frees itself from its gluten, mucilage, and tartar, and wine is the result.

Now, healthy urine, containing no sugar, does not ferment; but if we add yeast to diabetic urine at a temperature of from 70° to 80°, an effervescence shortly takes place, gas is evolved from it, and a peculiar vinous smell is observable. This fermentation test, as it is termed, is both a quantitative and a qualitative one, as we shall see further on.

What is termed the *alkali* test is used in Germany, but not so frequently in this country. It is only an approximate test, not giving accurately the amount of sugar present.

The urine is boiled with caustic potash, and if sugar is present it assumes a yellowish brown colour, and according to the intensity of colour the amount of sugar may be roughly estimated. This answers to our liquor potassæ test, described previously under the name of Moore's test.

Trommer's test is one of the copper tests for saccharine urine; it is applied as follows: Add a couple of drops of solution of sulphate of copper to one drachm of the urine in a test-tube, and then add liquor potassæ in excess, a precipitate of hydrated oxide of copper is thrown down, which redissolves in the excess of alkali in the presence of organic matter. If the solution in the test-tube is now boiled, a dense red precipitate of suboxide of copper will be thrown down if sugar is present, the colour of the precipitate, and density, depending upon the amount of sugar in the urine. No change takes place during ebullition if all traces of sugar are absent.

Before thoroughly understanding and appreciating the copper tests, we must be quite clear about the chemical changes which take place when we mix a solution of sulphate of copper with an alkali in the presence of sugar or other organic matter.

Oxide of copper is not soluble in an alkali when it is quite pure and free from organic matter; but if the liquid into which the copper solution is dropped, or the solution itself, contains sugar, which is an organic substance, then dissolution of the oxide takes place.

Fehling's solution is the test usually employed. In it we find the oxide held in solution by tartaric acid. This solution contains the various chemical ingredients required to produce the reaction necessary, and it can be kept ready for use in the dark in a glass-stoppered bottle. Lest any decomposition may have taken place in it, it is as well to boil the test solution occasionally before using, to be quite certain that no reaction has taken place.[1] The following is the correct formula for it: Dissolve 69 grains of sulphate of copper in five times its weight of distilled water, and add a concentrated solution of 268 grains of tartrate of potash, and then a solution of 80 grains of caustic soda in an ounce of distilled water.

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[1] Racemic acid is the product of decomposition, which

The solution used by Dr. Pavy is as follows: Sulphate of copper, 320 grs.; tartrate of potash (neutral), 640 grs.; caustic potash (potassa fusa), 1280 grs.; distilled water, 20 ounces.

Directions how to mix: First dissolve the sulphate of copper in 10 ounces of the water, and the tartrate of potash and potash together in the other 10 ounces of water. The copper solution is then to be added to the potash one. They must be mixed in the order above mentioned, or else a precipitate might be thrown down if the potash solution was poured first into the copper one.

These solutions are of a beautiful deep blue colour, and perfectly clear.

The fact that one equivalent of grape-sugar decomposes ten of sulphate of copper must be borne in mind as being the basis of this volumetric test of Fehling's. When we come to the

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takes place in the solution. Brande says racemic—from *racemus*, a bunch of grapes—is an acid found together with the tartaric acid in the tartar obtained from certain vineyards on the Rhine. It is the para-tartaric acid of Berzelius.

quantitative tests we shall have a practical illustration of it.

Tartaric acid seems to be the one organic substance which will permit of being boiled without allowing any reduction of copper. This vegetable acid holds free oxide of copper in solution and refuses to part with it even at 212° Fahr., or the boiling-point of water. (Pavy.)

So we must bear in mind that all copper solutions for test purposes consist of oxide of copper held in solution by an alkali, by means of organic matter which does not deoxidize it during boiling. If albumen is present in urine which is being examined, and any change has taken place in it resulting in the formation of ammonia and its compounds, these will exert a solvent action, upon the oxide of copper, and no precipitate will be thrown down by the sugar, if it is present in the urine. If we have found that albumen is in the urine, we must precipitate it and filter before applying the copper test.

When it is required to test a sample of urine, pour a little of the test solution into a large test-tube, and boil it, and then add a few drops of the urine, letting it trickle gently down the side of the tube; the effect of the cupric oxide reduction will be beautifully exemplified if there is much sugar present. Care must be taken that more urine than the bulk of the copper solution is not added. If very little sugar is in the urine. hardly any change takes place in the blue solution. If uric acid or colouring matter be present in abundance, they will produce discolorization of the blue test-fluid ; it is changed to a yellow colour instead of being converted into a heavy red precipitate, and the yellow is unaltered by boiling.

The test by the Polariscope.—Diabetic or grape-sugar has the power of turning the plane of the polariscope to the right, hence the origin of the term dextrine. The degree of rogation is in proportion to the amount of sugar present. If the urine to be examined is at all thick, it must be diluted before being tested by the polarizing saccharimeter.

Having enumerated the various qualitative tests for saccharine urine, let us now proceed to consider the various means at our disposal for calculating the *quantity* of saccharine material present in the urine of the diabetic. Without a knowledge of the amount which it contains it will be impossible for us to keep track of the progress or retrogradation of the disease in our patients; and our treatment must greatly depend upon the increase or decrease of the sugar.

Quantitative tests are now so simplified that the busiest practitioner can make use of them at all times.

The Quantitative or *Volumetric test*, as introduced by Fehling, is the one mostly used now for determining the amount of saccharine material in a given proportion of urine.

As has already been remarked, sugar always reduces copper in the *same* proportion, that is to say, 180 parts by weight of grape-sugar will decompose 1246 parts by weight of copper. The cupro-potassic solution is of such strength that 100 minims are discoloured by half a grain of grape-sugar. The oxide of copper, that is to say, contained in 100 minims of the solution, is reduced to a suboxide by half a grain of grape-sugar. In severe cases of diabetes in which the urine is very much loaded with sugar, it must be diluted to a known extent first. For this purpose we must use a tall glass tube, marked into a hundred equal divisions. Into this pour, say, twenty parts of urine, and then dilute it up to the hundred parts division with water; we shall thus dilute the urine with four times the amount of water, which is quite necessary if there is an abundance of sugar in it. A thorough admixture of the water and urine must be made in the glass measure. A pipette graduated precisely to 100 minims must now be filled with the cupro-potassic solution before described, and poured into a porcelain capsule; into this a small piece of caustic potash the size of a pea is to be put, in order to intensify the oxide precipitate, and so make the solution clearer. The capsule must now be heated over a spirit-lamp. Then fill the pipette with the diluted urine out of the graduated glass vessel up to the 0 mark, and drop the contents very carefully into the cupro-potassic solution in the capsule, while it is boiling over the spirit-lamp, keeping the solution in motion while the process is going on, by stirring it. Our object is, of course, to destroy, with the organic matter in the urine, the beautiful blue colour of the solution, and immediately this has been accomplished by the gradual dropping of the saccharine urine from the pipette, we must then read off the exact number of drops which have been allowed to escape. The operation however, must not be considered complete till every tinge of blue has disappeared from the copper solution, and a pure orange or red protoxide is precipitated. We have then to sum up the result.

As half a grain of grape-sugar discolours 100 minims of the cupro-potassic solution, and we have found it has taken 30 minims, we will say, of the diluted urine to produce this result; then 30 minims must contain half a grain of sugar, and as 30 minims goes sixteen times into a fluid ounce of 480 minims, therefore each fluid ounce of the diluted urine must contain 8 grains of sugar.

But we must not forget that we have added four parts of water to one only of urine. In order, therefore, to find out how much sugar there is in the urine *per se*, we must multiply the number of grains by five, so as to obtain a correct estimate of the amount of sugar in the pure urine. Thus $8 \times 5 = 40$, therefore 40 grains of sugar is the quantity per ounce.

We require, however, to find the whole amount excreted by the kidneys in the twenty-four hours. If the patient passes 12 pints or 240 ounces of water in that period of time, we shall find the total amount of sugar in it by multiplying 240 by 40, which gives us 9600 grains, or nearly 22 ounces, of sugar per diem. The following is the sum:—

$$\text{As } 30 : \cdot5 :: 480 : 8.$$

$$8 \times 5 = 40, \text{ and } 40 \times 240 = 9600.$$

The patient must be prevailed upon to collect all the water he passes in the twenty-four hours, that is, from going to bed on one night till the same hour the following night, calculating from after he has passed his water on the first night before getting into bed. It is always best to secure a specimen for testing of the water passed the last thing at night. (Pavy.)

The quantitative test by fermentation is carried out in the following manner: Fit a tube graduated into cubic inches with a cork perforated in its centre, and through the hole pass a bent glass tube. Fill the graduated tube with the urine under examination, and add a small piece of yeast to it, no air having been allowed to enter. The bent tube must be long enough to all but touch the bottom of the graduated glass; then plunge the apparatus into a receptacle filled with water at a temperature of about 80°. If sugar is concealed in the suspected urine in the tube, fermentative action will shortly take place, and carbonic acid gas will be given off, gradually displacing the urine as it collects in the top of the tube between the cork and the surface of the fluid. As the urine is forced down by the carbonic acid, it escapes upwards through the bent tube, and drops into a wine-glass which has been placed ready to receive it. Bearing in mind that one grain of sugar represents a cubic inch of carbonic acid gas, it will be easy, of course, to calculate the amount by observing the number of inches the urine has receded down the graduated tube. In this test we have a combination of the two kinds, namely, that for quality and for quantity.

Another simple plan of using the fermentation test is the following: Nearly fill a graduated tube with mercury, and fill it up with the urine under examination, first having added a small piece of yeast; then accurately cover the open extremity of the tube with the finger, and carefully insert it in a vessel containing mercury exposed to a temperature of 80°. The gas will rise and force down the mercury, and the displacement must then be calculated as before in the graduated tube.

Dr. Roberts simplified this fermentation test still further, in the following manner: He took two bottles, one eight and the other twelve ounces. He half filled the twelve-ounce bottle with urine, and the eight-ounce one he quite filled. Into the twelve-ounce bottle containing the urine he inserted a piece of German yeast, about the size of a raisin, cut into small pieces, the cork being grooved to permit the escape of the gas. The eight-ounce bottle, which he had quite filled with urine, he added no yeast to, and corked it tightly. Both bottles were then put aside for twenty-four hours in a warm place. At the termination of that period all fermentation would have ceased, and the specific gravity of each specimen was then carefully taken. If sugar had been in the urine, and fermentation in consequence taken place, it would have lost weight from two causes; first, because the saccharine material had been destroyed by the fermenting process, and, secondly, because the carbonic acid had been given off, and alcohol had taken the place of sugar. Each degree thus found to be lost represented one grain of sugar in the ounce. If the specific gravity had fallen twenty degrees, this represented twenty grains of sugar to the ounce of urine, and so on.

Now if this amount was multiplied by the total number of ounces of urine passed by the patient in twenty-four hours, it gave, of course, the quantity of sugar daily passed out of the system. If six pints was the quantity secreted, then the total amount could easily be calculated thus: 120 × 20 = 2400, representing 2400 grains of sugar.

There is a degree of inaccuracy in this quantitative test, because urine can absorb a large amount of carbonic acid, and, again, fermentation will not take place unless there are over two and a half grains of sugar in an ounce of the urine.

What is termed Dr. Duhomme's test is very similar to Fehling's, the difference only being a mechanical one.

Dr. Oliver has introduced, among other urinary tests, one for detecting sugar in the urine. It is both a quantitative and a qualitative test.

The fact of dyers extracting the beautiful blue colour from the indigo with glucose and alkali, before immersing their fabrics in the solution to be dyed, the blue colour being restored by the action of the oxygen in the air, suggested to him that if the blue could be removed by the admixture of these substances, why should not the same transformation take place if a solution of indigo and a caustic alkali was added to diabetic urine.

He therefore suspended indigo in a solution of carbonate of soda, and upon mixing it with some diabetic urine when heated, he found that all the colour was extracted from it, first changing from blue to green, then to violet, then to red, and finally to yellow. He found, however, that the solution would not answer when run into filtering papers, because the indigo would not leave the paper when once in it. With some little difficulty he succeeded in making certain chemical combinations with the carmine of indigo and carbonate of soda, and so forming a test-solution something similar to Fehling's in colour, but more of a greenish blue. The test-papers now in use are made from the constituents of this solution. These tests, Dr. Oliver states, have the following advantages: every paper is charged with the same definite quantity of the reagents; a uniformity is thus provided for the qualitative testing, which, moreover, becomes a standard of known value for the quantitative estimation. The colour of any remnant of the reagents left on the paper is completely discharged by the sugar, so that in the quantitative estimation the colourlessness of the paper will be found the guide as to the termination of the complete reaction.

In the *Lancet* of May 19th, 1883, will be found a full report of the very beautiful and interesting experiments, and their results, made by Dr. Oliver.

The test-papers are used in the following manner: Drop one of them into a half-inch test-tube, then add sufficient water to cover the top end of the slip; this will make a column of solution one inch high and half an inch in diameter, and always of the same concentration; then from a pipette drop one single drop of the suspected urine and apply heat. When the first change of colour takes place, remove the tube from the flame, and keep it hot over it, but not boiling; this causes the various beautiful changes of colour to take place in the usual order, namely, violet, purple, reddish purple, red, orange-red, and orange, and finally straw-colour, of which shade the solution remains. If these various changes of colour do not take place as above, a second drop of urine must be added, and a third, and so on till they do, for the sugar may be small in quantity. It is well to notice that over five or six drops of normal urine will produce a violet reaction, but no change beyond this.

One great advantage the indigo-carmine test has over all others, is that it will detect sugar at once in the presence of albumen, an advantage certainly not possessed by

Fehling's solution. Neither is it affected by uric acid in the urine, like Fehling's. Dr. Oliver states that he knows of nothing in the urine which will bring out the characteristic play of colours except glucose.

I would mention that in applying any of the tests for urine, it is best to use a long glass test-tube, quite eight or ten inches in length, for the fluid is not so likely to boil over. It requires no little skill to boil urine in a short narrow tube and not lose some of its contents. The tube should be about three quarters of an inch in diameter.

Dr. Ralfe's test for acetone in the urine: Dissolve four drachms of iodide of potassium in one ounce of liquor potassæ. Of this solution place one drachm in a test-tube, and boil thoroughly; carefully add a drachm of urine so as to float on the surface of the alkaline iodide solution.

At the line of junction a white cloud of phosphates will form, which after a short time will become yellow if acetone be present. On looking closer the feathery phosphates will be seen tipped with yellow points, where the iodiform is deposited; these, after a time, fall through the cloud and deposit at the bottom of the test-tube.

Picric Acid and Potash Test.—In 1883 Dr. George Johnson found that picric acid, when boiled with caustic potash, formed a very reliable and sensitive test for grape-sugar. He was at the time of his discovery quite ignorant of the fact that the same test had been discovered by Braun, a German chemist, twenty years before. A deep-red precipitate of picramic acid is thrown down in the testing-tube when sugar is present, which deepens according to the quantity of saccharine matter in the urine. As a quantitative test, Dr. Johnson gives the following formula for a standard solution to be kept always on hand for comparison. One fluid drachm of solution of grape-sugar, in the proportion of a grain to the fluid ounce. Mix it with half a drachm of liquor potassæ, P.B., and add ten minims of a saturated solution of picric acid, making up the mixture to four drachms with distilled water. Boil this mixture for sixty seconds, so as to insure complete reaction between sugar and picric acid. Whilst boiling, the pale yellow colour of the fluid is changed to a beautiful claret-red. The colour of the liquid is now that which results from the decomposition of picric acid by a grain of grape-sugar to the ounce four times diluted; that is to say, it indicates one quarter grain of sugar to the ounce. This colour is a most convenient one as a standard for comparison with the patient's urine under examination in the quantitative analysis.

Dr. Johnson suggests that, as the picramic solution changes slightly by exposure to light, becoming of a paler colour even in a few hours, an imitation standard test-solution, exactly representing it in colour, should be made as follows :—

℞ Liq. Fer. Perchlor. . .	ʒj.
Liq. Am. Acet. . .	ʒiv.
Acid Acet. Glacial. . .	ʒiv.
Aquæ distillatæ ad. . .	℥iis.

The instrument he uses for this standard test he terms a picro-saccharimeter.

Dr. Johnson further states that, since using the picric acid and potash test, he has so often found an excess of sugar in urine, when from the low specific gravity he should not have suspected it, that he invariably tests for both sugar and albumen in every specimen of urine. He uses the test thus :—

" To about one drachm of urine in a test-tube, add an equal volume of a saturated solution of picric acid. If albumen is present, the liquid is rendered more or less turbid, and this turbidity is increased by boiling. Then half a drachm of liquor potassæ must be added to the boiling mixture, and the albumen, if present, will be redissolved if the boiling is continued for thirty seconds. If sugar is present in the proportion of a grain to the ounce, the liquid will become darker than the quarter-grain standard, and two grains or more to the ounce will make the mixture black. The presence of an excess of sugar having thus been ascertained, the actual amount may be speedily and accurately determined by the quantitative method before described."

The presence of albumen has but little influence on the picric acid test for sugar; it has therefore this advantage over Fehling's test.

For a description of the "Ammoniated Cupric Test" of Dr. Pavy, I would refer the reader to the *Lancet* of March 1, 1884. Its composition is as follows:—

Cupric sulphate, 36½ grains; potassic sodic tartrate (Rochelle salts), 178 grains; potash (caustic), 178 grains; strong ammonia, 6 fluid ounces; water to 1 pint.

"Dissolve the potassic sodic tartrate and potash together in a portion of the water, and the cupric sulphate with the aid of heat in another portion. Pour the solution of cupric sulphate into the mixture of potassic sodic tartrate potash. When cold add the ammonia, and finally, with water, bring the volume of the fluid to the bulk specified." This test is not attended with precipitation of the reduced oxide. The blue colour is entirely removed, so completely that the solution looks like clear water, the ammonia dissolving the suboxide of copper entirely.

CHAPTER VII.

TREATMENT.

Before entering upon the subject of the treatment of diabetes, it will be very necessary to make some inquiries into the condition of the system of our diabetic patient, for, as we have already seen, there are two forms of the disease; in one of which the patient is fat and flourishing, and another in which the very opposite appearances present themselves.

In these latter cases the disease arises from "mal-nutrition," or a "lessened expenditure," from defective assimilation, whilst in the former there appears to be an over-production or "excessive formation," to use Dr. Harley's words. The patients in those cases arising from mal-nutrition look emaciated, pale, and debilitated, and generally miserable, with a peculiar wearied look in their faces; in fact, they are in that condition of body which is a natural sequence of gradual starvation.

It was this form of disease most probably which led Dr. Priory to use a saccharine diet for his patients, for he doubtless argued that, in order to prevent the body wasting away, he must give a fat and heat-producing diet, and he found these elements in starch and sugar. We must not suppose he acted upon the axiom "similia similibus curantur."

The saccharine treatment has, at all events, been tried and found wanting, and long ago given up.

Although, however, we must entirely discard a sugar and starch diet even in these cases, yet we must supply our patients with a diet liberally composed of the other elements—namely, the nitrogenous.

In the other form of the disease, or that which arises from an exaggerated formation of sugar from too liberal alimentation of sugar and starch, in which we find our patients fat in their bodies, florid in their faces, and hearty in their general appearance; our treatment must necessarily be somewhat different.

Formerly diabetes was looked upon as being necessarily a fatal disease; but since our knowledge, and more especially our physiological and chemical knowledge, of the human system, and, *pari passu*, our greater insight into diabetes, has increased, we are able to treat the disease more scientifically, and hence more successfully; in most cases being able to mitigate it, if we cannot remedy it. At all events we do not now, as our predecessors did formerly, view our diabetic patients as standing always upon the brink of a precipice, over which they must sooner or later fall as by an irrevocable decree. No doubt diabetics are more prone to contract certain diseases more readily than others, on account of the low state of vitality of their systems, and, when contracted, they are harder to throw off; hence we have seen that they are the victims of some skin-diseases, bronchial and lung affections, gastric complaints, especially catarrh of the stomach, constipation of the bowels, and kidney complications. We must, therefore, put our patients on their guard, and lay down certain stringent rules for their protection against the inroads of these affections. There is no doubt that we can bring more therapeutic agents to bear upon the disease in these days than our forefathers had at their disposal, and we have in our pharmacopœia certain drugs which we can use with very great success in our treatment of both forms of diabetes. Blood-letting was in vogue at one time, but has long been given up. It was advocated by Dr. Prout. He withdrew a small quantity of it from the epigastric region by cupping, and at the same time prescribed a liberal diet of farinaceous food and milk; but, as a consequence of this irrational treatment, he noticed disappearance of sugar in only one of his cases.

Our present knowledge of the pathology and physiology of diabetes teaches us, as we have already seen, to treat our patients very differently; but even in these days medical treatment must be considered in a great measure supplementary to a dietetic and hygienic one.

Patients must be given to understand very distinctly, when they place themselves in the hands of a medical man, that they must implicitly obey and systematically carry out the plan of treatment, especially that part of it which refers to the dietary, which he lays down for them.

The diet of diabetic patients must of necessity, as the chapter on physiology will have shown us very clearly, be of a strictly defined character. No sugar or starch must obtain access to the system. These ingredients of ordinary food, so necessary in the diet of healthy people, must be shunned as pernicious in that of the diabetic, for to him they are as fatal almost as the germs of typhoid fever. The smallest quantity of either of these carbo-hydrates entering the system will, in many cases, be quite sufficient to set up rapid fermentation.

Exercise is a most important factor in the treatment of the disease. Although it is a great mistake to carry it to the extent of over-fatiguing the already enervated body of the patient.

The nervous and muscular exhaustion thus produced would far more than counterbalance the actual good done. Gentle walking or riding exercise is most productive of good results. This may be carried to the extent of moderate diaphoresis.

The skin being thus acted upon relieves to a great extent the internal organs of the body, which otherwise would become sluggish in their action. I think it necessary to give this warning, for some patients are too apt to carry out their doctor's advice too literally and conscientiously, "to take plenty of walking exercise," and suffer in consequence.

The most agreeable and pleasant means to adopt in order to obtain a free action of the skin, and so relieve the over-worked kidneys, is the use of warm and Turkish baths. I think there are very few systems which would not be benefited by the latter, providing the temperature of the bath is not more than 160° Fahr., a moderate slight meal is partaken of previously, and a glass of cold water is drunk during the operation. Free application of cold water, in order to cause oxidation, is essential, to counteract the slightly debilitating effects of the heat. The Turkish bath certainly imparts a healthy action to the skin, improves the appetite, and gives tone to the assimilating organs generally. Once or twice a week is quite often enough to indulge in them. It is quite an error to suppose they make the bather susceptible to colds, for if ordinary care is taken by wearing flannel next to the skin, and not leaving the baths too suddenly, their effects are rather the contrary. If the patient is delicate naturally, apart from his ill-health caused by his complaint, why, of course, the baths must be modified accordingly; that is to say, he had better confine his operations to the cooler chamber, and the subsequent douche must be of tepid water. Many persons are discouraged at first from taking the bath, because they feel a depression resulting; but this feeling goes off entirely after the first few baths, and then their invigorating effects become apparent.

Dieting is, of course, our first consideration in the treatment of our patients, for, as we have seen whilst upon the subject of the physiology of the disease, the entrance of a fractional amount of sugar or starch into the stomach rapidly establishes the fermentative process, and the urine rapidly becomes charged with sugar. It is easy, therefore, to arrive at the conclusion that any article of food which contains either of these combustible fuels must be totally abstracted from the *cuisine* of the diabetic. Like a fire which dies out when the fuel which supports it is withdrawn, so sugar rapidly decreases in the urine when these chemical fuels are eliminated from the nourishment admitted to the stomach. But we must be careful on the other hand not to impoverish the system of our patients whilst thus carefully regulating their diet. We must bear in mind what is the character of the disease we are treating, whether it is nervous, hepatic, or alimentary in its origin, that is to say, whether it is the result of excessive formation of sugar, or whether it arises from defective assimilation; for in the former case the patient may be robust and even plethoric, and therefore prepared to be reduced a little; while in the latter he may be debilitated, thin, and ill-nourished, and requiring a more liberal diet, even to the extent of admitting animal milk and amylaceous food to his meals.

When the diabetic comes to us for the first time, it is best not to cut him off from his ordinary food too abruptly. We must let him down gradually, leaving off one article of sugary or starchy food after another, and substituting other foods for those we forbid, which will prove equally sustaining, but more azotic in their properties. The following diet-roll, compiled in a great measure from Professor

Church, Dr. Dobell, Bouchadet, and other works on food and its chemical ingredients, may be safely used by diabetic patients, from which to select three good, wholesome, and nourishing meals a day. This list contains all the flesh and force-producing agents, and it has been drawn up as elaborately as possible, in order that the patient may have a broad field to feed in, and not become heart-sick at the monotony of his food, in which case he is very apt to deceive his medical advisers, by taking forbidden food surreptitiously in sheer despair, and so injure himself. No arbitrary rule can be laid down as to the quantity of food to be consumed; the patient must eat what his stomach can manage. It does more harm than good "forcing himself to eat;" only part of the meal is digested, and the rest passes into the lower bowels undigested, to irritate the canal as a foreign body. If the digestion is weak, the rule must be little and often, and in the meantime medicine must be administered which will improve the tone of the system and assist in the assimilation of the food. It is very remarkable how quickly the intolerable thirst and voracious appetite is moderated by the dieting of the patient.

It remains doubtful as to what extent glycerine may be used in diabetes, or whether it should be used at all, except in enfeebled constitutions. It does not belong to the carbohydrates, but it has been found to produce increased alimentation of sugar in some cases. If, however, it is indicated, a mixture of it and claret wine is a most grateful beverage to the patient.

If the appetite fails we must withdraw our more rigorous restrictions upon the diet, even to the extent of giving milk and bread. Skim milk has been thoroughly tried and given up, although in very plethoric patients skim milk may be given at the expense of other foods.

Nothing much need be said about bran and gluten cakes, &c., for patients, as well as physicians, are perfectly familiar with them in all their varieties.

ARTICLES OF DIET PERMITTED.

Almonds.
Almond rusks.
,, biscuits.
Asparagus tops.
Artichokes.
Anchovies.
Ale, Burton, bitter.
Acid, hydrochloric, largely diluted with water, in medicinal doses.

B.

Bacon.
Butter.
,, milk.
Bran loaf.
Bread, stale, in moderation.
Bread, toasted.
Broccoli.
Beef tea.
Blatchley's bran.
Biscuits, Bonthron's.
Blanc-mange, made with almond, flour, cream, and gelatine.
Biscottes, Van Abbott's, and bread.

C.

Cream.
Custards without sugar.
Cheeses:—
,, Neuchatel.
,, Stilton.

Cheeses :—
,, Cream.
,, Gruyère.
,, Parmesan.
,, Dutch and other plain cheeses.
Caviare.
Cabbage.
Cruciferæ (all).
Coffee.
Cocoa nibs.
Cress.
,, water.
Capers.
Carraway.

E.

Eggs.
Endive.

F.

Fish (all).
Fat (all kinds).
Frogs, edible.
Fungi, edible.

G.

Game (all).
Gluten and almond biscuits.
Glycerine, with lime juice.

H.

Ham (unsweetened).
Horse-radish.

I.

Ice.
Isinglass.

J.

Jellies, unsweetened.
Jelly colloids.
* ,, ivory, without sugar.

K.

Kale, Scotch.
,, sea.
Kidneys.

L.

Lettuce, green leaves only.
Lime juice.
Lemon, slices, and cold tea.

M.

Meat, all kinds of fresh.
Meat, salted and preserved without sugar, honey, or treacle.
Meat, Bran's extract.
,, Liebig's ,,
Mutton broth.
Mushrooms.
Mannite in tea.
*Murdock's liquid food.
*Maccaroni gluten.
Marrows, vegetable.

N.

Nuts :—
,, Brazil.
,, Hazel.
,, Butter.
,, Filbert.
,, Walnut.

O.

Oils :—
,, Olive.
,, Cod-liver.

P.

Poultry (all).
Phosphoric acid, largely diluted.
Pickles.

Pepsine.
Pancreatic emulsions.

S.

Spinach.
Suet boiled in cream.
Sorrel.
Salad, green.
Spirits :—
  ,, Dutch Hollands.
  ,, Brandy and water, weak.
  ,, Whisky, old Scotch, or Irish.
Sweetbreads.
Sardines.
Soups, turtle, real or mock.
  ,, ox-tail.
*Semola gluten.

T.

Tea, with glycerine.
Turnip-tops.
Tripe.
Turtle.

V.

Vanilla flavouring.
Veal (if easily digested).
Vegetables of all kinds.
Vermicelli gluten.

W.

Waters :—
  ,, Spring.
  ,, Vichy.
  ,, Iced.
Waters :—
  ,, Soda.
  ,, Bethesda.
  ,, Glenn.
  ,, Carlsbad.
  ,, Vals.
  ,, Marianberg.
  ,, Brighton Seltzer.
  ,, Potash.
  ,, Aerated.
  ,, Carbonated.
  ,, Seltzer.
  ,, Lithia.
  ,, Apollinaris.

Carlsbad and Marianberg contain sulphate of soda, and are good as aperients.

Water, acidulated with acid tartrate of potash.
Wines :—
  ,, Dry Sherry.
  ,, Amontillado.
  ,, Sherry, Manzanilla.
  ,, Vino de Pasto.
  ,, Chablis.
  ,, Hock.
  ,, Sauterne Grave.
  ,, Hungarian, dry.
  ,, Bordeaux.
  ,, Burgundy.
  ,, Mâcon.
  ,, Beaune.
  ,, Médoc.
  ,, Ermitage.
  ,, Château la Rose.
  ,, St. Julien.
  ,, Chateau Lafitte.

All green vegetables are very wholesome, if well boiled in plenty of water.

Those articles marked with an asterisk are Van. Abbott's specialities.

ARTICLES OF DIET FORBIDDEN.

A.

Arrowroot.
Artichokes, Jerusalem.
Ales :—
  ,, Allsopp's pale.
  ,, Bass.
  ,, all sweet.
  ,, ginger.
Apples.
Apricots.

B.

Beetroot.
Beer.
  ,, lager.
Barley meal.
Beans, haricot.
  ,, broad.
Bananas.
Buckwheat.

C.

Cornflour.
Confectionery.
Carrots.
Crabs.
Chestnuts.
Cider.
Cauliflower.
Currants.
Cane-sugar.
Celery.
Cherries.
Citrons.
Chutney.
Cake, Pomfet.
  ,, Pontefract.
Curry powder.
  ,, paste.
Custard powder.
Chocolate.
Crystallized fruits.

D.

Dates.
Dari or Durra bread.

F.

Fruit, fresh.
  ,, dried.
  ,, crystallized.
  ,, syrup.
  ,, glacé.
Frumenty.

G.

Grapes.
Gum.
Gin, sweetened.
Gingerbread.
Groats, prepared.

H.

Honey.
Hominy.

I.

Italian paste.
Iceland moss.
Irish ,,

J.

Jaggary.
Jelly, guava.

L.

Lobsters.
Liqueurs.
Lemonade.

Lentils.
Lemons, pulp of.
Limes, fresh.
,, pulp of.
Liquorice.
Linseed.

M.

Maccaroni.
Maize.
Mussels.
Manna.
Maple-sugar.
Milk, cow's.
,, mare's.
,, goat's.
,, asses'.
,, skimmed.
Medlars.
Mustard.
Mangoes.
Marmalade.
Maltine.

N.

Nut, cocoa.

O.

Oatmeal.
Oswego flour.
Oranges.
Oysters.
Onions.

P.

Potatoes.
Pastry.
Parsnips.
Peas, green.
Pea flour.
Paddy.
Plums.
Pears.
Pickles, mustard.
Perry.
Porter.
Puddings, sweet.

R.

Rice.
Rye.
Raisins.
Rhubarb.
Raspberries.
Radishes.
Rum.

S.

Sugar, all kinds of.
Starch.
Sago.
Semolina.
Sweet potatoes.
Shalots.
Shaddocks.
Stout.
Spirits, raw.

T.

Tapioca.
Treacle.
Turnips.
Tomatoes.
Tamarinds.

V.

Vermicelli.

W

Wines, sweet.
,, Champagne.
,, Port.
,, Tent.
,, Marsala.
Wheat.
Whey.
Water melon.

Y.

Yams.

If the stomach cannot digest ordinary cooked meat, Dr. Brunton suggests that raw meat should be chopped up very fine, and eaten with pepper and salt. M. Victor Foucart, of 11, Passage Vero-dadat, Paris, manufactures a bread called "Pains pour gastralgiques de Gluten," which is very pleasant to eat buttered, and a nice change from the ordinary gluten breads in use.

In the medicinal treatment of diabetes we have not at the present time a very extensive list of drugs to make use of in our armoury. A few good ones are, however, better than a pharmacopœia of unreliable ones, and I think we have in certain preparations of opium, as codeia and opium itself, in the chalybeate tonics, alkalies, strychnia, cod-liver oil, iodide of potassium, certain mineral waters, and a few other valuable medicines, supplementary agents to our dietetic and hygienic treatment; for drugs alone, no more than the strictest dieting alone, will not cure the disease, or do more than relieve existing complications and symptoms as they arise; they must be supplementary the one to the other. Opium and codeia are perhaps the most serviceable drugs we can bring to bear upon the disease. Opium was first used in the commencement of this century. It has the power of diminishing nervous sensibility, and may therefore allay glycosuric irritation. It controls the voracious appetite of the diabetic, but we must be careful to discontinue the use of it as soon as ever it begins to impair the natural one. By thus checking the inordinate craving for food, and so reducing the intake of it, less sugar is, of course, admitted into the system; for there cannot be much doubt that, however careful the patient may be in restricting himself to foods which contain no starch or sugar, if much food is partaken of, those substances will gain admission, although in minute quantities. Thirst is also abated by opium and codeia, for they restrain the free action of the kidneys. Experience has proved that opium will in large doses actually check glycogenesis, and in some cases arrest the formation of sugar. We must watch very carefully that the bowels, always more or less troublesome in this disease, are not rendered more constipated by the use of the drug. If such is the case, a little colocynth must be added, to counteract its astringent properties. It exerts the greatest influence when diabetes is incipient. Opium has certainly risen more into favour of late, doubtless since diabetes has come to the notice of physicians, during the past few years, more in its earlier stages; it having become so much more general with practitioners to examine the urine of their patients. As a consequence diabetes can hardly obtain a foothold without detection. It is lamentable to think how at one time, even in our own days, diabetes passed unnoticed for months, and sometimes years, in people's systems, and when at length discovered, alas, it was too late for any drugs to have much effect upon the disease.

Patients had better not be placed on the opiate treatment too suddenly. The diet must first be regulated and modified according to the special diet manual, and then the opiates may be commenced in small doses, and gradually increased to very large ones; for we must not err on the side of deficiency, but rather go in for heroic doses, in order to affect our patient beneficially by it. The drug must be reduced in quantity, however, if the tongue becomes furred and the digestion is weakened by it, or if any symptoms of *coma* supervene; and here lies one of the dangers of opium, and special watch must therefore be kept for brain mischief. Codeia, the alkaloid of opium, may be given to begin with, in quarter, then half, and up to two grains three times a day.

The alkali treatment of diabetes was very fairly tried by Professor Trouseau in the Hôtel Dieu, Paris, but with very discouraging results. His theory was that if alkalies would neutralize sugar in the laboratory, they ought to do so in the human system. He seems to have given them in ordinary diuresis, or diabetes insipidus, but in combination with large doses of valerian, with remarkably good effect; but, as the latter drug is known to possess great virtues in diabetes insipidus, doubtless, had he left the alkalies out of his prescription, he might have witnessed the same good results. By his alkali and valerian treatment he frequently reduced the flow of urine from six pints to a pint and a half in the day, but he found, at the same time, that the patient became greatly debilitated under the alkali treatment; he therefore combined bitter infusion and chalybeates with them. Diabetes mellitus was but little affected, however, by the course of alkali medicines. By some pathologists the treatment has been carried out on purely chemical considerations, and by others on physiological grounds.

Some physicians in this country, looking upon the liver as the great sugar-manufactory of the body, have treated their patients with large doses of alkalies, hoping literally to destroy the sugar as it is formed, but they have not met with any more success than Prof. Trouseau. What combinations are effected in the laboratory cannot apparently be carried out in the human system. And even if alkalies destroyed sugar by combination in the body, it has yet to be proved that they can prevent its actual formation, that, in fact, they can check glycogenesis.

In the earlier stages of the disease patients may be greatly benefited by such alkalies as bicarbonate of soda, ammonia, lime-water, and magnesia, but in more advanced cases they cannot but prove injurious, owing to their weakening effects upon the system at large. Prof. Trouseau gave as much as half an ounce of bicarbonate of soda in the day, with the effect of not only weakening his patients by destroying their appetites, but of bringing on diarrhœa in some instances. Our great care must be in the treatment, whatever it may be, not to destroy the power of digesting food. We must check in a measure the voracity of the appetite, but at the same time, by judicious management of the particular case in hand, we must keep up sufficient tone in the digestive organs to permit of nourishment enough being taken to support the strength. Opium and alkalies in excess having both the tendency to check digestion, their effect must be carefully watched.

I would mention here *en passant* that, if pyrexia be present in the system at any time during diabetes, the sugar decreases in amount in an inverse ratio to the increase of the fever. We must not, therefore, be too ready to give the credit of the sugar-reduction to whatever drug we may be using at the time.

Strychnia is a drug much to be recommended for diabetes. It is borne well by the patient generally, and although perhaps it does not reduce the amount of sugar very much, yet it serves to keep up the tone of the nervous system, and to lift the patient along, as it were. If glycosuria is of brain-origin, as most physicians and pathologists consider it to be, it is a little difficult to recognize its action as a sugar-destroyer or preventer, for therapeutists tell us, as indeed experience has taught most of us, that strychnia affects but little, if at all, the brain-substance itself. It may, however, act through the spine upon the vaso-motor system, strychnia being essentially a spinal stimulant. Strychnia helps digestion wonderfully. As it enters the blood very rapidly, it is best to give it in small doses often repeated. When there is much flatulency, or other symptoms of mal-assimilation of the food, present, it is especially called for, and often acts magically upon the patient.

A little colocynth mixed with nux vomica makes an excellent aperient in the constipation attending the disease. If the heart becomes feeble in its action, this drug gives a tone to it.

It seems strange that strychnia and woorara should produce sugar in the urine if injected into the blood. I think Dr. Roberts mentions this fact in his work on medicine.

Cod-liver oil is a most invaluable drug, or, rather, nutriment, in diabetes, for it retards emaciation more than anything else, by re-forming the tissues. It is both heat-giving and force-producing. It is very easily digested, providing there is bile enough in the system to act as a solvent to it. It had better not be taken on an empty stomach, for it hinders the secretion of bile when taken quite alone; but mixed in with the food intimately it is readily taken up by the lacteals. Shortly after each meal is the most suitable time, and not just before going to bed, as some people take it. When taken on a full stomach, it becomes churned up with the rest of the food, and does not repeat so much, if at all. It is a mistake to take too much at a time, for a great portion will pass off with the stools. The best criterion to go by is the appearance or non-appearance of it with the evacuations. If the oil is observed passing away, reduce the dose. It is best taken on the top of a little syrup of oranges, or orange, or ginger wine; but the oil must be kept clear of the sides of the glass. The mistake people generally make is in sipping it, or swallowing it in a succession of swallows, instead of taking a small quantity, say one or two teaspoonfuls at a time, and tossing it off as Jack does his glass of grog. A clove then put in the mouth and sucked will generally remove any flavour which might remain. If, after "washing and rinsing your mouth, as you will, any taste of the cod oil should linger there still," then a small portion of salt will most effectually remove it. This oil increases the red corpuscles in the blood, hence its tonic properties. Should the stomach become irritable from the prolonged use of it, we must withdraw it entirely for a time. Except in large doses it will not often have this effect, nor will it produce, or even keep up diarrhœa if present, in small doses. Dr. Ringer thinks it a mistake to attribute the good effects of the oil to the very small quantities of iodine, phosphorus, and bile which it contains, but it is easily taken up, like all liver-fats, by the absorbents into the general system. These fats, he says, may be taken for months and years with perfect toleration by the stomach, whereas other fats, both vegetable and animal, often cause nausea, loss of appetite, and diarrhœa. Should, however, cod oil disagree at first, after the first week or two it can be borne easily, and in fact even relished by the patient.

Citrate of ammonia and iron in combination with columba bark is an excellent tonic. The ferri-ammonia citrate may be taken in a mixture with bicarbonate of potash and aromatic spirit of ammonia, and infusion of columba, made to effervesce with lemon-juice. Tonics of this kind should be persevered in for about a fortnight or three weeks, and then discontinued for a short time.

Cannabis Indica is a drug sometimes used in diabetes with varying results. Its primary effects are very exciting to the brain, upon which organ it seems to exert its principal effects. This drug has not the injurious effect of opium, that is to say, it does not produce constipation or sickness, or congestion of the brain. It may be given in half-grain doses to begin with, three times a day.

Conium has been recommended, but if, according to therapeutists, it paralyzes the vasomotor nerves, and the new theory is correct that this is one cause of diabetes, we must be careful how we use it.

Carbolic acid is sometimes used, but probably it benefits most those patients who have lung or bronchial complication.

The symptomatic treatment must be carefully attended to throughout the disease, in order to be prepared to meet every contingency as it may arise, such as attacks of dyspepsia, blood-derangement, nervous irritability, coma, &c. Transfusion of blood, and inhalation of oxygen gas, might be indicated in the latter emergency.

Some of the other drugs which are more or less useful in the disease are: ether, ergot, liq. pot., arsen., iodine, lactic acid, morphia, oxygen gas, pot. bromidii, phosphoric acid, pepsine, permanganate of potash, quinine. salicylic acid, sodæ lactatis, and valerian. This latter drug is mostly serviceable in diabetes insipidus.

THE END.

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